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OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

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1905.

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GENERAL REPORT.

The following report covers the work of the State Board of Health for the year ended Sept. 30, 1905. The report for the year ended Sept. 30, 1904, gave an account of the work performed in the field of water supply and sewage disposal during the year ended Dec. 31, 1904, and it was stated that, in future, the work of the department having to do with those subjects and that of all other departments would be reported upon up to a common date, namely, September 30. The Legislature of 1905, however, passed an act (chapter 211) establishing a new fiscal year, and providing that, beginning with the year 1906, all official reports should cover the work performed up to December 1, and be submitted on or before the third Wednesday of the succeeding January. Under this new order it would happen that, if the intended plan were carried out in the present report, the value of the reports on water supply and sewage disposal, so far as drawing comparisons of different years is concerned, would be seriously impaired, since the periods covered by the preceding, present and next annual reports would be respectively twelve, nine and fourteen months. It has been deemed best, therefore, to lengthen the period originally intended to be covered by the present report, and thus to diminish that which otherwise would have to be covered by the report for 1906. The arrangement that commended itself as least likely to impair the value of the reports for purposes of comparison was to allow the present one to cover the eleven months ended November 30, thus making the next, as well as all succeeding reports, cover one year.

The report on the examination of foods and drugs covers, as in all preceding annual reports, the year ended September 30. That on the production and distribution and use of diphtheria antitoxin, which, in the report for 1904, covered the six months ended September 30,[1] covers the year ended Sept. 30, 1905, as does also the report on the work of the diagnosis laboratory.

The usual report on "Health of Towns" is omitted in the present report, since the annual reports of the local boards of health from which it is compiled have not yet been issued, and will not be available for some months. In place thereof, accounts are given, in the Supplement, of

[1] The preceding six months' statistics were dealt with in the report for 1903.

investigations, made under the direction of the Board, of local outbreaks of typhoid fever in various parts of the Commonwealth.

For the same reason, Part II. of the customary "Statistical Summaries of Disease and Mortality," on "Fatality of Certain Diseases," and Part IV. of the same, on "Official Returns of Deaths in Cities and Large Towns" (section 12, chapter 75, Revised Laws) are omitted; but Part I., the "Weekly Mortality Returns," is submitted, and Part III., "Official Returns of Notified Diseases Dangerous to the Public Health," is submitted as Part II.

The report on "General Health of the State" in 1905, with the usual statistics of deaths and death-rates from certain diseases, is also necessarily deferred until the next annual report of the Board, since the returns for the year are not yet available.

A description of the new antitoxin and vaccine laboratory, with floor plans and half-tone illustrations, and a paper giving a ten-year retrospect of the production of antitoxin, both prepared by the pathologist of the Board, are presented in the Supplement, in which also are given the full details of the work performed by the various departments of the Board.

Water Supply and Sewerage.

The number of applications received by the Board for advice as to water supply, sewerage and sewage disposal and for the approval of sources of water supply and plans of proposed sewerage systems, under the general and special laws relating to these subjects, during the eleven months ended Nov. 30, 1905, was 105. The action of the Board in the matters considered during the year will be found in a subsequent portion of this report. Of the applications, 72 related to water supply, 7 to sources of ice supply, 21 to sewerage, drainage and sewage-disposal systems and 5 to miscellaneous matters.

Examination of Water Supplies.

Public water supplies were introduced during the year in the towns of Hadley and Holden, and at the end of the year 182 of the 354 cities and towns in the State were provided with public water supplies. All of the cities and towns of the State having a population, according to the census of 1905, in excess of 3,500 are now provided with public water supplies, except the towns of Barnstable, Blackstone, Chelmsford, Dartmouth, Dudley, Templeton and Tewksbury. The cities and towns having public water supplies contain approximately 93 per cent. of the population of the State.

Nearly all of the sources of public water supply in the State have been examined during the year by the engineer of the Board or his assistants,

and the usual chemical and microscopical analyses of the various waters have been continued. A few of the waters have also been examined bacterially. The chemical and microscopical analyses have been made at the laboratory of the Board in the State House, and the bacterial analyses at the Lawrence Experiment Station under the direction of the chemist of the Board.

The results of the chemical analyses have been summarized, and are presented in the chapter on "Examination of Public Water Supplies," together with such information as is deemed to be of special interest relating to the various sources.

There are several sources of public water supply in the State which are constantly polluted to such an extent that their waters must be regarded as unsafe for drinking. Most notable of these is the water supply of the city of Lynn, which is drawn from four storage reservoirs and from Saugus River. The water-shed of Saugus River contains practically all of the town of Reading and a portion of the town of Wakefield, a total population of about 9,000, or 769 persons per square mile. The sewage from a portion of the population in Wakefield is removed from the water-shed by the Wakefield sewers; but there is no public sewerage system in the town of Reading, and chemical and bacterial analyses of the waters of the streams which drain the thickly settled portion of this town show that they are grossly polluted.

The water of Saugus River is diverted through a canal and conduit, which tap the stream near the Montrose station on the Boston & Maine Railroad, into the Hawkes Reservoir, from which, during the past year, it is said to have been supplied to the Walden Reservoir and drawn thence to Birch Pond, from which it has again been pumped for the supply of the city.

During much of the year just closed the water in Hawkes Reservoir and in Birch Pond has been drawn down to a very low level, and the polluted water from Saugus River has been delivered to the city within a short time after its diversion from the river. Chemical analyses of the Lynn water show that there has been a decided deterioration in its quality within the past few years; and bacterial analyses of water during the past year from various parts of the system, both from the reservoirs mentioned and from faucets in the city, have shown the presence of bacteria in considerable numbers, including kinds characteristic of sewage, and there can be no doubt of the danger to which the health of those using the water is exposed under these conditions.

It is practicable, by extending a conduit up the valley of the Saugus River, to intercept the flow of Beaver Dam Brook and Pillings Pond water-sheds, tributaries of Saugus River, which might be used with safety, and to reject the polluted tributaries of Saugus River; and the

possibility of avoiding the use of objectionable parts of the water-shed of Saugus River in this way was brought to the attention of the Lynn authorities by the Board some time ago, but without effect.

The only other means of adequate protection of the public health, if the use of this source is to be continued, is filtration of the water before it is supplied to the city; and the further use of Saugus River as a source of water supply should be discontinued unless the water shall first be made safe for drinking.

The water supplied to the town of Franklin by the Franklin Water Company is drawn in part from wells near Mine Brook, and in part from Beaver Pond on the opposite side of Mine Brook, which is separated from the brook by a low ridge. An examination several years ago showed that, at times of high water in Mine Brook, water from this stream overflowed the ridge into Beaver Pond, which was being seriously polluted thereby. The attention of the water company was called to the danger to the health of those using the water at such times. A recent examination has shown that these objectionable conditions have apparently been made permanent by the raising of a dam on Mine Brook a short distance below the outlet of Beaver Pond, so that the water of Mine Brook can now flow at all times into Beaver Pond in the neighborhood of the point from which the water for the supply of Franklin is drawn.

Mine Brook is grossly polluted by manufacturing wastes, and also receives a large quantity of direct sewage pollution from water-closets in several factories along its course and from other places. The water company has again been warned of the danger to the health of the town involved in the continued use of the present sources.

One of the principal sources of water supply of the Great Barrington Fire District is Green River, which probably supplies four-fifths of the quantity of water used in the village. This stream drains an area of 52 square miles, 29 of which are within the limits of Massachusetts and 23 in the State of New York. Within the drainage area in New York are many dwelling houses and outbuildings, some of which are located on the banks of the stream and its tributaries, and there is a population of over 900 living within the water-shed in Massachusetts. The water supplied to the fire district is drawn directly from the stream, and under these conditions the continued use of this source is a menace to the health of the district, and the authorities of the district have been repeatedly so notified.

During the past year the Board approved plans for a new supply of water to be taken from Goodale Brook and adjacent streams which are not polluted; but, notwithstanding the objectionable conditions affecting the present source, the new plan was rejected by the district, which continues to use Green River as its main source of supply.

Several other cities and towns have been notified of objectionable conditions found in the course of the examination of water supplies during the past year, and have taken steps to secure more adequate protection.

Rules and Regulations for preventing the Pollution and securing the Sanitary Protection of Waters used as Sources of Public Water Supply.

Under the authority of chapter 75, section 113, of the Revised Laws, the Board, in response to petitions from local authorities, has established rules and regulations for the protection of the public water supplies in the city of Brockton and the towns of Westfield and Northborough. The regulations are in all respects similar to those which have been adopted by the Board in previous years for the protection of sources of supply in other places. As indicating the character of the rules and regulations adopted, reference is made to the rules and regulations adopted for the protection of the purity of the water supply of the city of Fall River, which will be found on page 22 of the report of 1903.

Water Supply of Lawrence.

In the report of last year the Board called attention to the urgent need of an additional supply of pure water for the city of Lawrence, and to the great danger that, owing to the fact that the consumption of water in the city in several recent winters has been greater, for periods of many days, than the capacity of the filter, it would be necessary to introduce the sewage-polluted water of the Merrimack River into the city's supply mains. On May 10, 1905, the following act was passed by the Legislature, to provide an increased water supply for the city: —

CHAPTER 389 OF THE ACTS OF 1905.

AN ACT TO PROVIDE FOR AN INCREASED WATER SUPPLY FOR THE CITY OF LAWRENCE.

Be it enacted, etc., as follows:

SECTION 1. The city of Lawrence, acting through its mayor and aldermen, shall forthwith increase the capacity of its works for filtering the water of the Merrimac river to such an extent as to insure at all times a sufficient quantity of water for the use of the public in that city, or it may take water from any spring, pond or well, in Andover, North Andover, Tewksbury or North Reading: *provided*, that no source of water supply for domestic purposes shall be taken or used under this act without the approval of the state board of health, and that the location of all filter galleries and wells, and the design of filters, shall be approved by the state board of health; and *provided, further*, that if water shall be taken directly from any pond or stream other than the Merrimac river, it shall be used only for the period of one year from the date of the passage of this act, and only in such quantities as the state board of health may deem necessary.

SECTION 2. Said city is hereby authorized and directed to raise and appropriate, in such manner as the city council shall determine, such sums of money as shall be requisite for carrying out the provisions of this act; and, if the city council shall so determine, the city may incur indebtedness for the purpose of obtaining money to such an amount as may be necessary for carrying out the provisions of this act, and may issue bonds, notes or scrip therefor.

SECTION 3. The city of Lawrence shall pay all damages to property that may be sustained by any person or persons by the taking of the waters of any stream or pond as authorized by this act, or in so far as the said city may diminish the flow in any stream or pond, or by the taking of any land, rights of way or easements, or by the erection of dams or the construction of any aqueducts, water ways or other works for the purposes of this act; and such damages shall be assessed and determined in the manner provided by chapter forty-eight of the Revised Laws.

SECTION 4. The towns of Andover, North Andover and Methuen, or any one of them, are hereby authorized to contract with the city of Lawrence, for a supply of water upon such terms and for such periods of time, not exceeding one year from the date of the passage of this act, as may be agreed upon by the mayor and aldermen of said city and by the selectmen of the town entering into the contract.

SECTION 5. The supreme judicial court shall have jurisdiction to enforce the provisions of this act.

SECTION 6. This act shall take effect upon its passage. [*Approved May 10, 1905.*

Subsequent to the passage of this act, a water supply committee was appointed by the city, and an investigation was begun with a view to obtaining a supplementary supply of water from tubular wells in the valley of a small tributary of Shawsheen River, which enters that stream from the west at Frye Village in Andover; and on April 28 the committee applied to this Board for its advice as to the use of water from the ground in this valley. The Board, after an examination of these wells, found that not only was the capacity of the proposed source too small to supply the quantity likely to be required, but that the water contained so large a quantity of carbonic acid that it would be likely to take up lead in such quantities in passing through the service pipes of the city (of which about 75 per cent. are of lead) as to cause lead poisoning, and the city was so advised on May 15, 1905.

On June 1, 1905, the committee requested the examination of the water of certain wells then being driven on the north bank of Merrimack River opposite Pine Island in the town of Methuen, as an auxiliary source of water supply for the city. The results of examinations showed that the water of these wells also contained an excessive quantity of carbonic acid; and the committee was advised that this source also was probably unsafe to use on this account, though a pumping test might show, after pumping had been continued for a time, that water obtained from the ground in this region would come mainly from Merrimack

River, and contain less carbonic acid, and the committee subsequently made a pumping test. The results of this test were unfavorable, and the city was so advised in a communication dated October 18, which, with other communications relating to this subject, will be found in the Supplement.

Since the completion of the pumping test, it does not appear that further action has been taken by the city to provide an adequate water supply during the coming winter.

Lead Poisoning.

Reference has often been made in these reports to the danger from lead poisoning in the use of lead or lead-lined pipes for the conveyance of drinking water; and many severe cases of lead poisoning resulting from the use of lead or lead-lined pipe have occurred in different towns in the State, — notably in Kingston, Fairhaven, Lowell, Milford and Milton, — which have been described in previous reports. While nearly all of the serious cases of lead poisoning resulting from the use of water from public water supplies have occurred in cities and towns supplied with ground water, and the quantity of lead found in surface waters delivered through lead pipes is usually small, there is, nevertheless, danger that, even where the supply is taken from surface sources, injury to health may result from the use of water drawn through lead service pipes. This danger has been emphasized by the discovery, during the past year, of the fact that the water of the Norwood water supply, drawn from Buckmaster Pond in Westwood, was taking up excessive quantities of lead from the lead service pipes through which it is supplied to consumers. An examination of this water several years ago did not show that its action upon lead pipe was sufficient to cause lead poisoning, but a change in the conditions has evidently occurred, the cause of which has not been definitely ascertained.

The soil in the region about the pond is coarse and porous, and the pond is fed mainly by springs. During recent years, owing to the increase in the use of water, the pond has been drawn to lower levels than formerly, and a greater proportion of the water doubtless comes directly from the ground.

Thus far the number of cases of lead poisoning reported has been small, and action has been taken by the town to provide for replacing the lead service pipes with pipes of other material. This change is necessary for the protection of the health of the users of the water, if the use of the present source is to be continued, and it is a desirable one in any case.

Character of Service Pipes used in Cities and Towns.

During the past year information has been sought from the various water-supply authorities in the State as to the character of the service pipes used in the different cities and towns, and the difficulties met with in the use of the different kinds. The results will be found in the Supplement. They show that in general the use of lead or lead-lined service pipes is common in the cities and larger towns in the State, in connection with the older water supplies. In a large number of cities and towns the use of lead has been avoided, and no serious difficulty has been experienced in the use of pipes of other material. The investigations show, however, that in some cases cities and towns have in recent years abandoned the use of pipes of other kinds and have begun the use of lead or lead-lined pipes, notwithstanding the objections to the use of this metal.

At North Andover, when the works were introduced, the water commissioners, acting under the advice of this Board, avoided the use of lead for service pipes, but it now appears that lead or lead-lined pipes are used for new services.

The information furnished by the various water departments shows that lead or lead-lined pipes are still used for new service pipes in 28 cities and towns, as follows: —

Andover,	Lawrence,	Revere,
Boston,	Lynn,	Sharon,
Brookfield,	Malden,	Somerville,
Chelsea,	Melrose,	South Hadley,
Chicopee,	New Bedford,	Stoneham,
Concord,	North Andover,	Swampscott,
Easton,	North Attleborough,	Wakefield,
Everett,	Plymouth,	Winchester,
Fall River,	Ipswich,	Woburn.
Haverhill,		

Lead is also used for new services to some extent in Ashburnham, Braintree, Framingham, Marlborough, Milton, Nantucket, North Brookfield and Reading.

In cases where the water of a public supply takes up excessive quantities of lead from service pipes it is, of course, essential that the lead pipes be removed, unless a change is made in the source of supply and a water is secured which will not do so; but nearly all waters take up lead in passing through lead pipes, and experience shows that a water which does not so act to a serious extent at one time may take up excessive quantities at another. The best plan is to avoid the use of lead or lead-lined pipe.

Waters which take up lead from lead service pipes are likely to attack a plain wrought-iron pipe or the zinc coating of a galvanized pipe, and to take up enough iron or zinc to make the water objectionable for some domestic purposes.

The experience of about 50 cities and towns with pipes lined with cement shows that this kind of service pipe is satisfactory, and it has, of course, no objectionable effect upon the quality of the water passing through it.

Tin pipes and pipes of other materials lined with tin, when properly made, also have no unfavorable effect upon water supplied through them, and are practicable and satisfactory. It is important, however, that in the use of tin-lined lead pipes the tin be of sufficient thickness to prevent the water from coming in contact with the lead.

Results of Experiments upon the Use of Copper Sulphate in the Removal of Microscopic Organisms from Ponds and Reservoirs, and in the Use of Copper and Copper Sulphate for the Destruction of Bacteria.

Many experiments have been made, under the direction of the Board, upon the use of copper sulphate for destroying objectionable growths in drinking-water reservoirs and upon the use of copper vessels for holding water, in order that bacteria and disease germs in the water may be destroyed.

Anabœna, Oscillaria and other troublesome organisms of the *Cyanophyceœ* were destroyed by the application of 1 part of copper sulphate in 4,000,000 to 8,000,000 parts of water; while other organisms, some of which were objectionable, appeared to be unaffected; and still others grew more abundantly.

Our experiments in reservoirs show that we cannot expect even dissemination of the copper sulphate through the water: in some cases the larger amount tended toward the bottom; in others it was all found in layers near the top. In some cases the larger part of it adhered to or was absorbed by floating organic matter, and remained where this floated; in others it went to the bottom with the organic matter, to remain until the latter disintegrated, then to be again taken up by the water. It is probably due to this localization that fish were killed in large numbers with a dose of copper sulphate which would be small if disseminated throughout the reservoir, while in other reservoirs few or none were killed, when larger amounts were applied.

This uncertainty of evenness of dissemination adds much to the danger from the application of this poisonous substance to drinking waters.

It having been stated with some authority that sewage-polluted water retained in copper vessels for a few hours would have its dangerous

bacteria killed and be rendered harmless for drinking, experiments were made for the purpose of determining the effect of copper vessels upon such bacteria, as well as the effect upon them of placing in the water strips of copper, and also the effect of adding to such water copper sulphate, sulphate of alumina and ferrous sulphate.

In copper vessels containing polluted water the number of ordinary bacteria sometimes increased for two days, then decreased more rapidly than in crockery vessels, but persisted for several weeks. In other copper vessels the bacteria decreased from the start, but continued in considerable numbers for a week and in small numbers for many weeks. The distinctive sewage bacteria, B. coli, were not found after the first day in one case, but in other cases they were present in considerable numbers for from three to ten days.

Broth cultures of B. coli diluted with sterile water and put into copper vessels gave varying results. In one case 99 per cent. died in twenty-four hours; a few were alive on the sixth day. In another case few were alive at the end of the first day and very few on the second and third days, but these increased to large numbers on the eighth day, and in the third case they remained in large and nearly constant numbers five days and disappeared on the tenth day. In a similar dilution of broth culture B. typhosus diminished rapidly during six hours, and after twenty-four hours the organisms disappeared.

Putting the same quantity of sewage-polluted water into several glass vessels, and inserting into the water of all but one of them a thin strip of polished metal of the same size in each instance, the bacteria became fewer in number than in the vessel containing no metal, in the following order: iron, tin, aluminum, zinc, copper and lead. B. coli disappeared in nearly the same order.

The results of many experiments are given in the Supplement, showing the effect of the application of different proportions of copper sulphate upon the bacteria in water. Reference will here be made to a few of the results.

With large quantities of copper sulphate, when the water is given a strongly astringent taste, the dilution being 1,000 parts or 10,000 parts of water to 1 part of copper sulphate, the general result is the killing of nearly all of the bacteria in a short time, although in some cases they afterward begin to grow and then multiply very rapidly.

With 100,000 parts of water, in most cases the bacteria were nearly all killed at first and then multiplied, often to many times the original number; in one case they increased rapidly from the first. B. coli and B. typhosus from laboratory cultures disappeared in twenty-four hours or sooner.

With 1,000,000 parts of water, the water bacteria kept up with the control or increased beyond it. B. coli naturally in the water did the same, but laboratory cultures disappeared in two days. Nearly all typhoid bacilli direct from laboratory culture were killed in six hours, but a few survived five days; but where the typhoid bacilli had lived in the water a few days before the copper sulphate was applied, which is more nearly their natural condition when found in water, they increased after the first hour and continued higher through the ten days of observation.

With 10,000,000 parts of water, the effect upon the water bacteria was nearly the same as with the dilution last mentioned. B. coli naturally in the water continued to show larger numbers than the control. B. coli from laboratory culture were killed in three days. Nearly all typhoid bacilli disappeared in one case in four hours and in another case in three days; but those from a culture that had grown four days in the water before the copper was introduced increased steadily during four days and remained higher than the control at ten days.

With 100,000,000 parts of water similar results were obtained.

In all of these experiments with bacteria in their natural condition, when the dilution was as great as 100,000 parts of water to 1 part of copper sulphate, a stage of growth was reached in which the number of bacteria was much greater than the original number, indicating that their growth was greatly stimulated by the copper sulphate.

Examination of Rivers.

Examinations of the various rivers of the State by means of chemical analysis of samples collected at various points have been made as in previous years. The effect on the pollution of streams by the discharge of sewage from cities, towns and manufacturing establishments continues to increase with the growth of the population and manufacturing in the State. The condition of each stream was reported in detail in 1902, and under the circumstances a detailed statement of the further observations is not at present deemed necessary.

Pollution of Charles River.

During the summer a petition was received from persons living near Charles River in the town of Milford, alleging a serious nuisance there by reason of the pollution of the river by the sewage of the town. Investigations by the Board in 1902 had already shown that the stream was grossly polluted in its upper waters by sewage from Milford and by sewage and manufacturing wastes in Franklin. An investigation of the

conditions complained of by the petitioners was made by direction of the Board, which shows that there are two principal sewer outlets discharging into the river in Milford. The water-shed of the stream in the neighborhood of these outlets is but 10 square miles, and much water is drawn from it by the Milford Water Company for the supplies of Milford and Hopedale. Under the circumstances, for periods of several months very little water flows in the stream, which is in a state of gross pollution at such times for a distance of several miles. There is a large population living near this portion of the stream in the town of Milford, and the conditions here are prejudicial to the public health. On October 5 the Board brought the matter to the attention of the local authorities, in a communication a copy of which may be found in the Supplement. No reply has been received to this communication, and the Board brings the matter to the attention of the Legislature, for such action as it may deem desirable.

The Board is informed that the town of Franklin is preparing plans for sewers designed to remove and purify all of the sewage and manufacturing wastes which now pollute the tributaries of Charles River in Franklin.

The Neponset River.

Many complaints have been made of the condition of Neponset River, which appears to have been more offensive than usual throughout its course during the summer.

During the year 1905, settling tanks having a capacity of about 600,000 gallons were installed at the tannery of the Winslow Bros. & Smith Company at Norwood, and since early in July all of the offensive wastes from this establishment have been passed through the tanks before being discharged into Hawes Brook. The work of constructing filter beds for the further purification of the effluent from these works after it is passed through the settling tanks was also begun, but had not been completed at the beginning of cold weather.

Plans for the purification of the sewage from the town sewer of Norwood were also presented to and approved by the Board near the end of the year, with the proviso that the works shall be completed and sewage diverted from the river by July 1, 1906.

The installation of the settling tanks at the tannery has already prevented the entrance of much objectionable matter into the stream, and the completion of the works now under construction and of the filter beds designed for the purification of the town sewage will effect a great improvement in the character of the effluent from two of the principal sources of pollution in the upper waters of the stream.

The most difficult problem thus far met with in preventing the pollution of this stream has been the purification of the wastes of the large paper mills at East Walpole. The quantity of polluted water discharged from these mills is very large, and the area available for its purification is limited. These wastes contain, moreover, organic matter which is very stable in character, and not acted upon by the usual precipitants, unless in excessive quantities. Early in the year two of the principal manufacturers constructed, at their own expense, experimental tanks and filters, and began experiments upon the purification of the wastes, in co-operation with the Board. These experiments were begun in June and have been continued to the present time. The results thus far obtained indicate that it will be practicable to purify these wastes at reasonable expense, but it is essential that the experiments be continued for some time longer, in order that the best practicable and reasonably available method may be determined.

In the lower part of the valley an experimental filter has been installed at the large paper mill at Mattapan, and experiments have been begun upon the purification of the wastes from this establishment. It will be necessary to continue these experiments for some time before adequate information can be obtained on which to base the design of works for purifying these wastes.

Experiments are being made in the laboratory upon the treatment of wastes from one of the principal woolen mills on Mother Brook.

Examination of Sewer Outlets and the Effect of Sewage Disposal.

The examinations of sewer outlets during the year 1905 have been confined chiefly to investigations of the effect of the discharge of sewage into Boston harbor. Observations have been made during the year of the effect of the discharge of sewage from the three principal sewer outlets into the harbor, — those of the Boston main drainage system at Moon Island and the north and south metropolitan sewer systems at Deer Island and Peddock's Island, respectively. In connection with these observations, numerous chemical and bacterial analyses have been made of the waters in all parts of the harbor, as well as in the portions affected by the discharge of sewage from the main sewer outlets.

In addition to the discharge of sewage at the main outlets, a large quantity of sewage overflows at times of rain from the combined sewer systems in Boston, Cambridge, Somerville and Chelsea into the waters of the upper harbor and the estuary of Charles River, and to a smaller extent into Mystic and Neponset rivers. A considerable quantity of sewage is discharged directly into the harbor or its tributaries at all

times from a few sewers not connected with the metropolitan system, chiefly in Chelsea. A large part of the sewage of the city of Chelsea is discharged directly into the harbor instead of into the metropolitan sewerage system, which was designed to receive it, the reason being, apparently, the neglect of the Chelsea authorities to maintain their sewers in such condition that the sewage can reasonably be admitted to the metropolitan sewerage system. Besides the sewage from these outlets and from the storm overflows, the harbor receives a considerable quantity of direct pollution by sewage from buildings and wharves along the harbor fronts of the cities and from vessels, and a small quantity of sewage is discharged from institutions on the islands.

The odor from the Moon Island outlet is offensive for a distance of half a mile from the outlet under ordinary conditions, and is noticeable at times at greater distances. At Deer Island an odor is rarely noticeable at a distance of more than a quarter of a mile, while at Peddock's Island an odor is observable at the present time only immediately about the outlet.

Chemical examinations of the harbor water in the region affected by the discharge of sewage at the Moon Island outlet and of the harbor water at other points in this neighborhood during the past summer have shown that the sewage does not spread materially outside of the area in which it is visible by inspection. Some effect of the sewage is nearly always noticeable, by chemical and bacterial analysis, in the area over which the Moon Island sewage flows twice daily. In the vicinity of the outlet and along the sea wall extending about 1,500 feet southeasterly therefrom, deposits collect in summer, and when the wind is off shore combine, with the effect of an eddy, to retain some noticeable effect of the sewage in this region.

At Deer Island chemical analyses show that the sewage is confined to the narrow field in which it is ordinarily visible on the incoming tide. On the outgoing tide the sewage from this outlet flows directly to sea.

Chemical and bacterial examinations of samples of the water from all parts of Boston harbor, both on the incoming and outgoing tide, and from points outside the harbor, show that, while the sea water from outside the harbor is low in bacteria and free from B. coli, the characteristic organism of sewage, nearly all of the samples collected inside the harbor, on the other hand, contain comparatively large numbers of bacteria, and in all but two samples out of more than 100 in this series the Colon bacillus was found to be present.

The chemical analyses show, in general, results similar to the bacterial analyses, the water of all parts of the harbor containing a higher

free ammonia than is found in water from outside of the harbor. The least evidence of pollution was found in Hingham Bay, where the free ammonia and the bacteria present were lowest; while the greatest pollution was found in the waters of the inner harbor, *i.e.*, in the portion of the harbor between Governor's Island and the mouths of the Charles and Mystic rivers.

Careful examinations of the shores of the harbor show that they are in general affected but slightly by the presence of matters discharged from the main sewer outlets. The only matters found upon the shores which could be identified as probably derived from sewer outlets were grease balls and particles of grease. The grease balls are formed in the sewers around pieces of cork, matches or other floating objects, and these and the light particles of similar greasy matter float upon the water and are carried for long distances from the sewer outlets. This matter is found on the islands and the shores in all parts of the harbor excepting in the southerly part of Hingham Bay, and is found to some extent along the outer shores outside of the harbor entrance. The quantity at all places is very small, and in most places it can be detected among the seaweed and other débris along the shores only by a most careful inspection.

The results of the examinations of the sewer outlets and the effect of sewage disposal in Boston harbor show that the waters of all parts of the harbor are affected to some extent by pollutions from the sewers and by the other wastes from the great population about it.

The most seriously polluted portion of the harbor at the present time is the inner harbor inside of Governor's Island. The pollution of this portion of the harbor is caused in part by the discharge of sewage from buildings and wharves on the harbor front, which might be connected with the local sewers, and in a large part by the direct discharge of sewage from sewers in Chelsea, East Boston and some other places.

By the provisions of chapter 439 of the Acts of the year 1889, entitled "An Act to provide for the building, maintenance and operation of a system of sewage disposal for the Mystic and Charles River valleys," any city or town within whose limits any main sewer should be constructed under the provisions of the act was required to connect its local sewers with such main sewer, subject to the direction and control of the (then) Metropolitan Sewerage Board. Some of the principal sewers in Chelsea have been connected with the metropolitan sewerage system under the provisions of that act; but the connection has subsequently been discontinued in one case, the Board is informed, by the city, and in another case by the Metropolitan Sewerage Board, by reason of the neglect of

the city to provide for the proper maintenance of its sewerage system, and for the prevention of the entrance of matters which might tend to obstruct or impede the flow of sewage.

There appears to the Board to be no means by which the Metropolitan Water and Sewerage Board or other authority can regulate the connections of sewers with the metropolitan sewerage systems, or prevent the apparently unnecessary discharge of sewage into local waters in cities and towns in which sewers have been constructed for the purpose of removing sewage and preventing such pollution; and the Board brings the matter to the attention of the Legislature, and recommends legislation to provide for such regulation and for the prevention of unnecessary pollution of Boston harbor and tributary waters.

Results of Investigations as to the Use of Shellfish taken from Polluted Waters.

From the investigations made by the officers of the Board during the past five years we find reason to conclude that oysters, clams and other shellfish, when grown in unpolluted water, are free from bacteria or other organisms which we associate with disease-producing germs; that when grown in or when exposed for a short time to sewage-polluted water these shellfish take into the water within their shells and into their bodies the sewage bacteria that are associated with such disease germs; that the methods of keeping such shellfish in the market do not destroy these bacteria; that the eating of shellfish which have been in sewage-polluted water is likely to be injurious to health and to endanger life. This is especially the case if they are eaten raw, and the danger is not removed by the usual methods of cooking, such as the steaming of clams, the making of oyster stew or even the frying of oysters. Sufficient cooking to insure the destruction of the dangerous bacteria renders the shellfish unpalatable. The only safe method is to use clams and oysters that have grown and have been fattened in water unpolluted by sewage.

The careful survey of Boston harbor, reported in the Supplement, indicates that no part of it is sufficiently free from sewage pollution to be a safe place for growing or fattening clams or oysters.

Investigations upon the Purification of Sewage and Water at the Lawrence Experiment Station.

In sewage filtration special studies have been made during the year of the operation of the original sand filters constructed at the station from 1887 to 1890. Owing to many years' application of sewage, these filters have accumulated much stable organic matter, especially within

their upper portions. This organic matter has been the subject of considerable investigation during the year, and it has been proved to be very largely of a carbonaceous instead of a nitrogenous character. The amounts of various kinds of organic matter present have been determined from time to time throughout the year, and the filters have operated in a manner favorable to the oxidation and removal of this matter. Owing, also, to methods of operation followed during the year, these old filters have produced better effluents than for several years past. Many additional data have been obtained during the year in regard to the operation of septic tanks, contact filters, intermittent-continuous filters, etc., and various investigations in regard to improved methods of analysis of sewage and sewage effluents have been made.

The experiments on the filtration of water have been continued as in previous years, the special subjects investigated being the operation of filters with the use of a coagulant to improve bacterial efficiency, double filtration of polluted water and the use of copper sulphate in water filtration. Very extended studies have been made also in regard to the value of copper sulphate as a bactericide, and special experiments have been carried on along various lines in connection with the use of this salt as an algicide in the treatment of water supplies.

As in previous years, a large amount of work has been done in examining water and shellfish from various shellfish areas, together with various experiments in regard to the destruction of bacteria in shellfish by heat.

Food and Drug Inspection.

The work of the Board in the inspection of food and drugs, which has been conducted since 1882, has been productive of much improvement through the strict enforcement of the law concerning proper labelling, especially with regard to the presence of chemical preservatives, which are, or have been, used very extensively in meat products, shellfish, various preserves and malt liquors. The issuing of warnings in cases of non-compliance with this law having been found to be regarded apparently as a mere form, devoid of special significance, the practice was stopped, and prosecutions were substituted. The methods followed in the collection and examination of articles deemed worthy of attention have undergone no marked alteration. Samples are purchased in the open market by the inspectors, and are submitted by them to the analysts for examination. The laboratory receives also, under proper conditions, through the secretary of the Board, under whose direct supervision all of the work of this department is conducted, samples brought by citizens; but no reports are given for use in advertising. The number of samples of foods and drugs collected and examined during the year ended Sept.

30, 1905, was 6,104, and the total number since the work was begun in 1882 has now reached 163,460.

During the year 313 prosecutions were brought in the various courts of the Commonwealth, bringing the total number to 2,101. As stated above, the detailed reports of this branch of the work of the Board are presented in the Supplement.

Inspection of Liquors.

In 1902 the Legislature abolished the office of inspector and assayer of liquors, and transferred the duties thereof to the Board. Samples of liquors of various kinds seized or otherwise obtained by the police throughout the Commonwealth are received and examined by the analysts with special reference to the percentage of alcohol contained. The report on this branch of work will be found following that on food and drugs.

Inspection of Dairies.

While the condition of the public milk supply so far as standard quality and adulteration are concerned has received for many years the degree of attention prescribed by the statutes relating thereto, no special legislation requiring examination of the conditions under which milk is produced, handled and stored for purposes of public sale has been passed. On account, however, of the intimate connection existing between unclean milk and infantile mortality, the Board, acting under its general authority to conserve the public health and to "make sanitary investigations and inquiries relative to the causes of disease,"[1] began on March 1, 1905, a systematic examination of dairies and of the cows belonging thereto, employing for the purpose a skilled veterinary surgeon of large experience. Detailed reports are submitted, on blank forms specially provided, to the secretary, who, in case of the existence of conditions inconsistent with the production of clean, sanitary milk, communicates directly with the farmer, or with the milk contractor to whom the milk is shipped, or with the board of health of the city or town in which it is sold, calling attention to objectionable features and suggesting remedies for their correction. As may be seen by reference to the blank form of report, which is herewith presented in reduced size, examination is made of the cows as to health and cleanliness; of the cow stable as to cleanliness, cubic space per cow, ventilation, light, drainage and other sanitary conditions; of the source of water supply for watering stock and washing cans and other utensils, as to possible pollution; and of conditions affecting the wholesomeness of the milk at the time of production and during storage and transportation.

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[1] Section 4, chapter 75, Revised Laws.

COMMONWEALTH OF MASSACHUSETTS.

STATE BOARD OF HEALTH.

INSPECTION OF DAIRIES.

City or town ______________________ Date ______________ 190___

Name of owner ______________________ Time of visit ______________ M.

Number of cows ______________________ Number of cow stables ______________

Condition of cows (1) as to health ______________________
(If any are sick, note same on reverse side of blank.)

(2) as to cleanliness ______________________

Condition of Cow Stables: —

Construction ______________________ Approximate cubic space per cow ______________

Means of ventilation ______________________ Condition as to light ______________

Nature of floor of cow stalls ______________________ Means of drainage ______________

Are the cows bedded? ______________________ If so, with what? ______________

Where is manure stored? ______________________ How often removed? ______________

Is hay stored where cows are kept? ______________ Are horses kept in same stable? ______________

General condition as to cleanliness ______________________

Water Supply: —

Source of supply (*a*) for watering stock ______________ (*b*) for washing cans, etc. ______________

Distance of latter from (*a*) stable ______________ (*b*) possible source of pollution ______________

Direction of ground level from each such source ______________________

Milk: —

Are the udders cleaned before milking? ______________ If so, how? ______________

How is the milk cooled? ______________________

Where is it cooled and handled? ______________ Where is it stored? ______________

Where are cans, etc., washed? ______________ Where kept during milking? ______________

Has the owner an ice house? ______________ Is ice easily obtainable in the vicinity? ______________

How much milk is sold? ______________ To whom is it shipped? ______________

How far is it hauled for delivery? ______________ At what hours is it hauled? ______________

If delivered at a railway station, how long a time is likely to elapse before it is taken into the car? ______________________

SIGNATURE ______________________

Inspector.

MEMORANDA AS TO DISEASED COWS.

NAME OR NUMBER OF COW.	Condition.

Remarks: —

During the seven months ended September 30, 2,151 farms were visited and reported upon. Of this number, 431 were found to be free from objectionable conditions; but concerning 1,720, or 80 per cent., letters were sent by the secretary calling attention to a total of 4,793 defects of various kinds, and suggesting appropriate remedies therefor. So far as has been ascertained, the recipients of the letters have shown generally a commendable spirit to conform to the suggestions offered. The results of the investigation are presented in full detail in the Supplement.

Inquiries into the Causes of Local Outbreaks of Infective Diseases.

During the period covered by this report the assistance of the Board in discovering the immediate cause of outbreaks of infective disease, and abating the same, was invoked by individuals or local authorities of the following places: Amesbury (scarlet fever), Bedford, Blandford, Chelsea, Chester, Easthampton, Everett, Hanover, Ipswich, Lynn, North Oxford, Plymouth, Rockland, Springfield, Swampscott, Waltham, Westfield, Woburn and Wrentham (all of typhoid fever), Southbridge (diphtheria) and Springfield (trichinosis). Examinations were made in each case by agents of the Board, and the reports based thereon are presented in the Supplement. The medium through which the dissemination of the infective agent occurred was found to be, in most cases, polluted milk.

Nuisance alleged and complained of by the Winter Hill Improvement Association and Others against the Hinckley Rendering Company of Somerville.

At the regular monthly meeting, held on September 7, a petition was presented from the Winter Hill Improvement Association and 199 others, alleging that the Hinckley Rendering Company of Somerville was conducting its business in such a manner as to be a public nuisance, and requesting the holding of a public hearing, at which evidence in support of the allegation would be presented. It was voted to hold a public hearing on Thursday, October 5, at 12 o'clock, which fact was duly advertised in the "Somerville Journal" of September 22 and 29.

On September 29 the plant mentioned was visited by the committee on health of towns, and the secretary, and it was inspected in all its parts.

At the hearing on October 5 the petitioners were represented by counsel. Some twenty witnesses appeared in person, and testified to facts within their knowledge in support of the petition. The Hinckley Ren-

dering Company also was represented by counsel, who requested a continuance of the hearing, and it was voted that a second hearing be given on Friday, October 13. At this second hearing a number of residents and representatives of the company were heard in opposition.

Representatives of the Board visited the works again on October 19 and November 1, and later made a report of their observations to the Board. After full consideration of all of the evidence before it, the Board voted at the regular meeting, held November 2, to send the following communication to the Hinckley Rendering Company: —

OFFICE OF THE STATE BOARD OF HEALTH,
STATE HOUSE, BOSTON, Nov. 2, 1905.

To the Hinckley Rendering Company, Somerville, Mass.

GENTLEMEN: — In response to a petition of the Winter Hill Improvement Association and numerous persons living in the neighborhood of your works, alleging the existence of a nuisance by reason of the offensive odors arising therefrom, the State Board of Health has given a public hearing after notice to the parties interested, and has examined the works and their surroundings. Much evidence was presented at this hearing to show that persons living near these works are affected by the offensive odors coming therefrom.

Upon the occasions when the buildings and their surroundings have been examined by the Board or its officers the condition of the buildings as regards cleanliness has been satisfactory, but offensive odors were noticeable at a considerable distance from the works. Much foul drainage is discharged from the works through drains leading to the Mystic River in the rear of the buildings, where the drainage is discharged upon flats exposed at low tide; and a large area of flats in the neighborhood of the buildings is at present covered with a deposit of sludge evidently derived from the wastes discharged from the works.

The Board has been thus far unable to determine to what extent the serious odors complained of are due to the emanations from the works themselves, and what proportion of them is derived from the offensively polluted flats near the buildings; but in any case Mystic River is not the proper place of disposal for foul drainage from these works, and the Board would recommend that they be discharged into the public sewers. If this shall be done, and the offensive deposits removed from the flats before the coming of warm weather again, it will then be practicable for the Board to determine what further measures, if any, may be required to protect the public health and comfort in this locality.

The Board would suggest that keeping the doors and windows closed so far as practicable, and providing a system of ventilation discharging into the main flue, would aid materially in preventing the escape of odors from these works.

Nuisance alleged and complained of by the Mayors of Chelsea and Somerville against the Works of the New England Gas and Coke Company of Everett.

At the regular monthly meeting of the Board, held on May 4, 1905, petitions were received from the Hon. Edward E. Willard, mayor of Chelsea, and from the Hon. Leonard B. Chandler, mayor of Somerville, alleging that the works of the New England Gas and Coke Company, situated in Everett, constituted a nuisance prejudicial to the health, well-being and business interests of their respective cities, because of escaping gases and noxious odors, due to the methods of manufacture and to the manner of disposal of the by-products and wastes; and praying that a public hearing be granted for the presentation of evidence, and that, the fact being proved, steps be taken to cause an abatement of the conditions complained of. The Board took immediate action, and voted to give a hearing on May 18, which fact was duly advertised in newspapers published in Boston, Somerville, Chelsea and Everett, and communicated in writing to the officers of the said company. On the date mentioned numerous witnesses were heard, who gave testimony in proof of the allegation. The works of the company were visited and examined by the Board and by the engineer and secretary, and it was determined that the cause of the nuisance lay largely in the improper treatment and disposal of the spent lime from the purifying boxes, from which were given off the nauseous odors which, when the direction of the wind was favorable thereto, were conveyed into the houses of not only the communities bringing the complaint, but of certain sections of Boston, Cambridge and elsewhere.

At the regular June meeting of the Board representatives of the company appeared and were given a hearing, in the course of which suggestions were made for an amelioration of the conditions, and plans were submitted by the representatives of the company, which promised a reasonably prompt solution. Subsequent visits were made to the works by representatives of the Board, and it appeared that the company was making proper efforts to abate the nuisance by structural changes and by improvement in the methods of handling and disposing of the spent lime.

On July 12, letters were sent to the respective mayors of Chelsea and Somerville, requesting that they would assist the Board by furnishing the names of persons living in the sections affected by the odors, who would be willing to send word to the office by telephone or otherwise whenever the same were markedly serious. Answers were received at once, from the mayor of Somerville, giving the names of six representative citizens to whom letters had been sent requesting their co-operation,

and from the mayor of Chelsea, stating that he had requested several citizens living in different parts of the city to supply the information requested. From the latter no information has thus far been submitted, but from all of the former letters were received in the month of September, as follows: —

(1) I am very glad to inform you that the odors from the New England Gas and Coke Works have not been very noticeable for the past two months. In fact, I do not recall any time when they have been very bad since the hearing was held at the State House. We had on Monday and Monday night a very strong easterly wind and heavy fog with it, and those are the conditions under which we usually get it; but it was not noticed at all.

(2) There has been a great improvement in conditions during the last few weeks, and I have detected very little odor during that time. Only on one or two occasions have these odors been at all marked, and at those times they were nothing as compared with the former conditions. I wish to congratulate you on your success in so promptly producing such a marked improvement.

(3) I have not, for the latter part of the summer, noticed nearly as much odor from the gas plant as formerly, and we hope that a method has been devised which has abated the nuisance.

(4) I have made some little investigation, and find that there is not nearly so much complaint in regard to the odors from the New England Gas and Coke Works lately as there was in the first of the summer. I have heard of the odor being present in Somerville only two or three times since then, and then not nearly so strong as formerly.

(5) I have not for several weeks found any odor of hydrogen sulphide coming from the lime-purifying process in the atmosphere. At one time, about fourteen to twenty days after the hearing by the State Board of Health at the State House, there was a stench at about 3 A M. This was the last I recall. I have given especial attention during the past few weeks when in a position for the wind to bring the fumes directly to me, and I have not found the presence of the offensive sulphide of hydrogen.

(6) The following are dates on which the New England Gas and Coke odor has been noticed here: June 30, 8 to 11 o'clock A.M.; July 3, 11 A.M. and after; July 11, 5.30 A.M. and all day; July 21, at noon and after; July 23, 12.30 to 4 P.M.; July 24, 4 P.M. and after; July 30, A.M.; August 5, during night; August 6, 3 P.M. until evening; August 14, 9.50 A.M. and after; August 15, at night; August 17, noon and after; August 8, strong, part of day. Since August 18 we have noticed only an occasional faint odor. We get the odor when the wind is about easterly. The gas works are about N. 78° E. (true) from our house.

On the other hand, a number of citizens of Everett and one in Chelsea have complained that but little improvement has been made; but visits to the works are convincing to the contrary. While a marked improvement in conditions has been brought about, much still remains to be done, and the company has been notified that the necessary changes must be made within a reasonable time.

Investigation of the Sanitary Conditions of Factories, Workshops and Other Places of Employment in the Commonwealth.

The special report made by the Board of the investigation conducted under the terms of chapter 99 of the Resolves of 1904 led to the passage of another resolve by the Legislature of 1905, as follows: —

Chapter 59 of the Resolves of 1905.

Resolve to provide for Continuing the Investigation by the State Board of Health of Conditions affecting the Health or Safety of Employees in Factories and Other Establishments.

Resolved, That the state board of health, with such aid as it may require from the chief of the district police and from the bureau of statistics of labor, is hereby directed to continue the investigation of conditions affecting the health or safety of employees in factories, workshops and other places of employment in the Commonwealth, the said investigation having been authorized by chapter ninety-nine of the resolves of the year nineteen hundred and four. For this purpose the officers and employees of the said board shall have power to enter and inspect all premises in use for industrial purposes, and to obtain such information as may be necessary to carry out the purposes of this resolve. The board is also directed to report to the general court on or before January fifteenth in the year nineteen hundred and seven, such recommendations as it may deem expedient for the revision of the laws in this Commonwealth relating to the health, safety or welfare of persons engaged in industrial pursuits. For the above purposes the board may expend a sum not exceeding twenty-five hundred dollars during the fiscal year nineteen hundred and five, and twenty-five hundred dollars during the fiscal year nineteen hundred and six. [*Approved April 28, 1905.*

Under this new resolve three inspectors were appointed, and they entered immediately upon the duty of making an exhaustive investigation. Since the terms of the resolve provide for a report in January, 1907, no results or conclusions will be given in the present report.

Routine Work of the Board.

Statistical Table for the Year ended Sept. 30, 1905.

Whole number of samples of food and drugs examined during the year,	6,104
Samples of milk examined (included in the foregoing),	3,164
Whole number of samples of food and drugs examined since beginning of work in 1883,	163,460
Whole number of samples of milk examined since beginning of work in 1883,	90,468
Number of prosecutions against offenders during the year,	313
Number of convictions during the year,[1]	289

[1] 24 cases pending.

Amount of fines imposed during the year,	$8,486
Number of packages of antitoxin of 1,500 units each issued to cities and towns,	47,387
Number of tubes of vaccine issued to cities and towns,	23,870
Number of bacterial cultures made for the diagnosis of diphtheria in cities and towns,	3,382
Number of examinations made for diagnosis of tuberculosis,	1,090
Number of examinations of blood made for diagnosis of malarial infection,	21
Number of examinations of blood made for the diagnosis of typhoid fever,	459
Number of notices of cases of infectious diseases received and recorded under the provisions of chapter 75, section 52, Revised Laws,	18,053

Force employed in general work of Board at central office, State House: —

Secretary,	1
Assistant to the secretary,	1
Clerks,	5
Messenger,	1
Total,	8

Force employed for food and drug inspection: —

Chemists and assistants,	3
Inspectors,	3
Total,	6

Force employed at laboratory (Bussey Institution): —

Pathologist,	1
Assistants,	6
Total,	7

Under the Provisions of Chapter 375, Acts of 1888.

Applications for advice from cities, towns and others: —

Relating to water supply,	72
Relating to ice supply,	7
Relating to sewerage and drainage,	21
Relating to pollution of streams,	1
Miscellaneous,	4
Total,	105

Number of samples of water, ice and sewage examined chemically and microscopically at the laboratory, Room 502, State House,	5,780
Number of samples of sewage, water and ice examined chemically and bacterially at the Lawrence Experiment Station,	2,389

Number of samples of sand examined chemically at the Lawrence Experiment Station,		264
Number of samples of sand examined mechanically at the Lawrence Experiment Station,		104
Additional samples examined bacterially at the Lawrence Experiment Station,		2,145
Samples of water, ice, etc., examined for bacteria, B. coli and sewage Streptococcus at the Lawrence Experiment Station,		4,764
Number of shellfish examined for B. coli and sewage Streptococcus,		1,305
Total number of samples examined,		16,751

Force employed at central office: —		
Chief engineer,	1	
Assistant engineers,	7	
Stenographers and clerks,	3	
Messenger,	1	
	—	12
At laboratory, Room 502, State House: —		
Chemist,	1	
Assistant chemists,	6	
Biologist,	1	
Stenographer,	1	
	—	9
At Lawrence Experiment Station: —		
Assistant chemists,	2	
Bacteriologists,	2	
Other assistants and laborers,	3	
	—	7
Total ordinary force,		28

The number of applications for advice under the provisions of the acts relating to water supply and sewerage, received since July, 1886, when these acts first went into operation, is as follows: —

1886,	8	1897,	59
1887,	22	1898,	75
1888,	28	1899,	79
1889,	38	1900,	104
1890,	23	1901,	105
1891,	53	1902,	93
1892,	56	1903,	129
1893,	51	1904,	125
1894,	53	1905,	105
1895,	52		
1896,	65	Total,	1,323

APPROPRIATIONS.

The appropriations for the year 1905, as recommended by the Board in the annual estimates made under the provisions of chapter 6, section 26, of the Revised Laws, were as follows: —

For the general expenses of the Board,	$21,000
For the inspection of food and drugs,	12,500
For the production and distribution of antitoxin and vaccine,	10,000
For the purity of inland waters,	34,000
For the examination of sewer outlets and Neponset River,	7,500
For printing the annual report,	4,000
Total,	$89,000

EXPENDITURES.

The expenditures in 1905 under the different appropriations were as follows: —

Appropriation for general expenses of Board,	$21,000 00

General Expenditures, Sept. 30, 1904, to Sept. 30, 1905.

Salaries,	$10,654 75
Travelling expenses,	1,665 30
Stationery,	267 65
Printing,	1,153 07
Books, subscriptions and binding,	857 44
Advertising,	18 10
Express charges,	259 37
Extra services,	691 21
Messenger,	111 22
Postage and postal orders,	670 15
Telephone and telegraph messages,	127 29
Typewriting supplies,	125 39
Special investigations,	167 41
Office supplies,	896 00
Laboratory supplies,	2,284 01
Miscellaneous,	172 68
Total,	$20,121 04

Expenditures for the Production and Distribution of Antitoxin and Vaccine for the Year ended Sept. 30, 1905.

Appropriation,	$10,000 00
Salaries,	$3,831 04
Printing,	186 22
Amount carried forward,	$4,017 26

Amount brought forward,	$4,017 26
Laboratory supplies,	1,008 38
Rent of laboratory building,	1,000 00
Laboratory construction,	395 18
Express,	96 40
Books,	23 00
Purchase of animals,	·486 00
Board of horses,	1,795 75
Food for animals,	280 52
Rental of telephone, and messages,	124 65
Extra services,	6 00
Ice,	29 85
Miscellaneous,	38 53
Total,	$9,301 52

Expenditures under the Provisions of the Food and Drug Acts during the Year ended Sept. 30, 1905.

Salaries of analysts,	$5,014 99
Salaries of inspectors,	4,059 99
Travelling expenses and purchase of samples,	1,992 83
Apparatus and chemicals,	814 31
Printing,	28 78
Services, cleaning laboratory,	86 00
Express and telegrams,	13 38
Sundry laboratory supplies,	132 55
Typewriting supplies and stationery,	10 10
Books,	51 93
Extra services,	181 00
Total,	$12,385 86

For carrying out the Provisions of the Act to protect the Purity of Inland Waters, and to require Consultation with the State Board of Health regarding the Establishment of Systems of Water Supply, Drainage and Sewerage.

Appropriation,	$34,000 00
Salaries, including wages of laborers at Lawrence Experiment Station,	$25,571 31
Apparatus and materials,	3,361 13
Rent of Lawrence Experiment Station,	150 00
Use of tools and office, Lawrence Experiment Station,	329 84
Travelling expenses,	1,842 39
Express charges,	1,150 32
Books, bookbinding, stationery and drawing materials,	452 18
Maps and blue prints,	284 98
Telephone and telegraph messages and postage,	55 00
Amount carried forward,	$33,197 15

Amount brought forward,	$33,197 15
Typewriting supplies,	89 57
Extra services,	228 64
Services, reading gauges and collecting samples,	59 00
Miscellaneous,	424 82
Total,	$33,999 18

For the Examination of Sewer Outlets, under the Provisions of Section 4 of Chapter 75 of the Revised Laws.

Appropriation,	$7,500 00
Salaries,	$5,747 37
Apparatus and materials,	25 70
Travelling expenses,	1,344 01
Express,	1 50
Telephone and telegraph messages,	5 62
Services, collecting samples and reading gauges,	125 00
Extra services,	138 15
Miscellaneous,	112 03
Total,	$7,499 38

HENRY P. WALCOTT.
CHARLES H. PORTER.
JULIAN A. MEAD.
HIRAM F. MILLS.
JOHN W. BARTOL.
GERARD C. TOBEY.
JAMES W. HULL.

SUPPLEMENT.

WATER SUPPLY AND SEWERAGE.

ADVICE TO CITIES AND TOWNS.

ADVICE TO CITIES AND TOWNS.

Under the provisions of the Revised Laws (chapter 75, section 117), the State Board of Health is required to

consult with and advise the authorities of cities and towns and persons having, or about to have, systems of water supply, drainage or sewerage as to the most appropriate source of water supply, and the best method of assuring its purity or as to the best method of disposing of their drainage or sewage with reference to the existing and future needs of other cities, towns or persons which may be affected thereby. It shall also consult with and advise persons engaged or intending to engage in any manufacturing or other business whose drainage or sewage may tend to pollute any inland water as to the best method of preventing such pollution, and it may conduct experiments to determine the best methods of the purification or disposal of drainage or sewage. No person shall be required to bear the expense of such consultation, advice or experiments. Cities, towns and persons shall submit to said board for its advice their proposed system of water supply or of the disposal of drainage or sewage, and all petitions to the general court for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of said board thereon.

During the year 1905 the Board has given its advice to the following cities, towns and persons who have applied for such advice under the provisions of this act or under special acts relating to water supply and sewerage.

Official communications were made during the year under the provisions of acts relating to water supply and to sources of ice supply, as follows: —

WATER SUPPLY.

Ashburnham.
Barnstable (Hyannis Fire District).
Bellingham (well at schoolhouse).
Bellingham (Caryville).
Bridgewater and East Bridgewater.
Brockton.
Chelmsford.
Dracut.
Falmouth.
Fitchburg.
Foxborough (State Hospital).
Gloucester (Y. M. C. A.).
Gloucester (well on Cole's Island).
Great Barrington (three).
Hadley.
Hardwick (Wheelwright).
Holden.
Holyoke (well in Germania Park).
Holyoke (Chemical Paper Company).
Holyoke (American Writing Paper Company).
Holyoke (three wells).

Lawrence (five).
Leicester.
Lynn (J. B. Renton & Co.).
Medford (Medford Boat Club).
Mendon.
Methuen.
Milton (Leopold Morse Home).
Nashawena Island (proposed State Prison).
Newburyport.
Northampton (Mt. Tom Sulphite Pulp Company).
Northborough.
Northbridge.
Norwell.
Norwood.
Palmer.
Peabody (two).
Penikese Island (proposed State Prison).
Pepperell.
Royalston.
Russell.
Salem.
Scituate (E. C. Carlton).
Southbridge.
Spencer.
Spencer (Isaac Prouty & Co.).
Springfield (three).
Springfield (springs).
Stoughton.
Sturbridge.
Uxbridge.
Waltham.
Waltham (U. S. Watch Company).
Waltham (American Waltham Watch Company).
Wareham (Onset).
Westborough (Insane Hospital).
Westfield (two).
Westfield (militia camp).
West Island (proposed State Prison).
Wilmington (Walker School).

Ice Supply.

Chicopee.
Dartmouth.
Holyoke (two).
Mansfield.
Nahant.
Westfield.
Weston.

Official communications were made during the year under general and special acts relating to sewerage and sewage disposal, as follows: —

Cohasset and Hull.
Duxbury.
Fairhaven.
Foxborough (State Hospital).
Haverhill.
Holyoke.
Longmeadow.
Marion (three).
Milford.
Northampton.
Norwood (two).
Norwood (Winslow Bros. & Smith Company).
Pittsfield.
Rockland (E. T. Wright & Co).
Rhode Island (State Board of Health).
Salem.
Somerville (Hinckley Rendering Company).
Taunton.
West Bridgewater (Howard Seminary).
Weston.
Weymouth.
Worcester (Insane Hospital).

Public Institutions.

Massachusetts School and Home for Crippled and Deformed Children.
Rutland (Hospital Prison for Consumptives).

Water Supply.

The following is the substance of the action of the Board during the past eleven months in reply to applications for advice relating to water supply: —

Ashburnham.

May 4, 1905.

To the Board of Selectmen of the Town of Ashburnham, Mr. Henry C. Newell, *Chairman.*

Gentlemen: — The State Board of Health received from you on March 18, 1905, an application for advice with reference to a proposed additional water supply for Ashburnham, to be taken from the ground in the vicinity of Philips Brook east of the railroad in Ashburnham, or from the ground in the vicinity of the railroad and pond in South Ashburnham, or other suitable location, depending upon the results of tests then about to be made with a view to supplying Ashburnham from one or the other of these sources in connection with the present system, and also furnishing a supply of water to South Ashburnham. The tests made subsequently with a view to obtaining a ground-water supply from the places indicated proved unsatisfactory, and other sources were then investigated by your engineer, one being a small brook flowing from Brown Hill east of the village of Ashburnham; another, Upper Naukeag Pond, northwest of the village; and a third, the brook flowing from Reservoir Pond northeast of the village; and the Board has caused these sources to be examined by one of its engineers.

The water of the stream flowing from Brown Hill is of good quality, and it appears to be practicable to build a storage reservoir of sufficient size upon this stream to secure enough water from it for all the requirements of the present village of Ashburnham; but the area of the water-shed is small, and the capacity of the source would not be sufficient to furnish all of the water required in case the works should be extended to furnish water to the village of South Ashburnham.

Either Reservoir Pond or Upper Naukeag Pond would furnish much more water than would be required for both villages. The water of Reservoir Pond is, however, quite highly colored, and would be objectionable at times for drinking and other purposes. The water of Upper Naukeag Pond is naturally of good quality for the purposes of a public water supply; but the pond is used extensively as a summer resort, especially at the end from which the water would naturally be taken for the supply of Ashburnham, and the protection of the pond from pollution would probably add considerably to the cost of taking water from this source. The conditions about the southerly end of the pond are such that it may be practicable to obtain water from the ground by means

of wells or a filter-gallery in sufficient quantity for all the requirements of Ashburnham; and the Board would recommend that further investigations be made with a view to obtaining a supply of water for the town from the ground in this locality.

The Board will assist in further investigations, if you so request, by making the necessary analyses of samples of water, and will give you further advice when the results of further investigations are available.

Barnstable (Hyannis Fire District).

Dec. 7, 1905.

To Messrs. E. A. Baxter and I. C. Sears, *Water Supply Committee, Hyannis Fire District, Hyannis, Mass.*

Gentlemen: — The State Board of Health received from you on Oct. 12, 1905, an application for advice as to a proposed water supply for the Hyannis Fire District in the town of Barnstable, accompanied by plans and a report of your engineer describing the proposed works.

According to the plan, the supply is to be taken from a system of tubular wells to be located near the northeasterly side of the Barnstable road, and 1,100 feet north of Main street at the railroad crossing.

In response to this application the Board has caused the locality to be examined by one of its engineers, and has caused a sample of water taken from a tubular well known as Chase's well, at the site at which it is proposed to locate the system of tubular wells, to be analyzed, and has also caused analyses to be made of samples of water from other wells in this neighborhood.

The results show that the water of the Chase well contains a much larger quantity of iron than is found in good ground waters, and, so far as can be judged from this examination, water taken from the ground at this locality would be likely to be objectionable for domestic purposes. The water from the other wells was of considerably better quality in most respects, and the quantity of iron present in these wells was insignificant.

There is very little doubt that an ample supply of water for the requirements of the village of Hyannis can be obtained in the extensive sandy plain north of the village; but it is very important, in the opinion of the Board, that the source be located at a considerably greater distance from the village than the place now proposed, and at some place where the water is not affected by an excess of iron.

The Board would advise that further investigations be made by means of tubular wells at some point north of the village and a quarter of a mile or more from the nearest house. The Board will, if you so request, assist you in further investigations by making the necessary analyses of the water, and will give you further advice when you have the results of further investigations to present.

Bellingham (Well at Schoolhouse).

July 6, 1905.

To the Board of Health of the Town of Bellingham.

Gentlemen: — In response to a request of the superintendent of schools for an examination of the water of a well which is the source of drinking-water supply of the school situated on the easterly side of Hartford Avenue between the villages of North Bellingham and Caryville, the State Board of Health has caused the well to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water is grossly polluted, evidently by drainage from the vaults of the school, which are located within a very short distance of the well.

The Board would advise that the further use of water from this well be prevented without delay, and that a new source of water supply be provided for the use of the school.

Bellingham (Well at Caryville).

Sept. 7, 1905.

To Mr. C. E. White, *Chairman, Board of Health, Bellingham, Mass.*

Dear Sir: — In response to your request of July 20, 1905, the State Board of Health has caused the well of E. B. Stowe near the railroad station at Caryville to be examined by one of its engineers and a sample of the water of the well to be analyzed.

The analysis shows that the water has been badly polluted, and, though subsequently partially purified in its passage through the ground, it contained when examined a large number of bacteria, including kinds which are characteristic of sewage. The pollution of the well is evidently caused by sewage and other wastes which enter the ground from buildings in its immediate vicinity, and the Board would recommend that the further use of this well be prevented.

It appears to be practicable to locate a well in this neighborhood at a considerably greater distance from sources of pollution than this one, and secure water which would be safe for drinking.

Bridgewater and East Bridgewater.

May 4, 1905.

To the Bridgewaters Water Company, Mr. Joseph Weeks, *Treasurer.*

Gentlemen: — The State Board of Health received from you on March 29, 1905, the following application for advice with reference to the use of a proposed filter for purifying the water of the Town River, which you propose to use as a source of additional water supply: —

An increased supply of water for our Bridgewater plant having become a necessity, we have under consideration the installation of a gravity filter plant of the type manufactured by the New York Continental Jewel Company, the Greer

Filter Company, the Jackson Filter Company and others, taking water from the Taunton River.

Our Mr. Mayo left at your office yesterday a proposal submitted to us by the Greer Filter Company, and before proceeding further with our negotiations with them or other manufacturers, we desire to know whether or not this type of filter would meet with the approval of your Board.

In their proposal you will notice that they guarantee the water flowing from their filter will meet the State requirements; but we would like to have, as soon as possible, your consent or disapproval, which we, of course, know must necessarily be obtained before erecting the filter. If the plan submitted does not meet your approval, we desire to seek an additional supply in another direction.

The application is accompanied by plans of the proposed filter, which is apparently to be located in the neighborhood of your present pumping station, taking water from the Town River in the neighborhood of your present wells.

The plans provide for a filter having a diameter of 15 feet, which is to contain about 30 inches of sand above a layer of gravel, and underdrains designed with means for stirring and cleaning the sand. Settling tanks are provided in connection with this plant, and the water is to be treated with alum before filtration. The rate of filtration would apparently be about 74,000,000 gallons per acre per eight hours or more.

The Board has caused your present sources to be examined, and has considered the plans of the proposed filter and the records of numerous analyses of the water of the Town River now on file in the office of this Board, and the results of examinations of its sanitary condition.

Town River above the location of the proposed filter drains an area of somewhat more than 50 square miles, containing several villages, with factories and other places by which the river is polluted; and analyses show that so much sewage and polluting matter enter the stream that this water would without doubt be injurious to the health of those who might use it for drinking, unless it were thoroughly purified at all times. The water of the Town River is also highly colored, and contains a large quantity of organic matter taken up from the swamps on its water-shed and in its natural state would be a very objectionable drinking water, even if unpolluted by sewage.

The experience of the Board in the purification of water by filtration shows that this water could not be efficiently purified by the plan now proposed, so that it would be either safe for drinking or satisfactory for other domestic purposes, and the Board cannot recommend the adoption of this plan. Moreover, it would be very difficult, in the opinion of the Board, to purify the water of the Town River by any practicable method to such a degree that the water would be of satisfactory appearance for domestic use.

The quantity of water which the Bridgewaters Water Company is capable of supplying from its present sources is evidently inadequate for the requirements of the towns of Bridgewater and East Bridgewater. An additional supply should be provided with as little delay as possible, since it has already been necessary, the Board is informed, to use water directly from the Town River, greatly jeopardizing the health of the people of these towns.

The Board would recommend that you employ an engineer of experience in matters relating to water supply, to make investigations and prepare plans for securing a sufficient additional quantity of good water to meet all of the requirements of the towns now supplied from your works. The Board will assist you in these investigations, if you so request, by making the necessary analyses of water, and will give you further advice when the results of investigations are available.

Brockton.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on May 4, 1905, for preventing the pollution and securing the sanitary protection of the waters of Silver Lake and its tributaries, used by the city of Brockton as a source of water supply.

Chelmsford (Well at North Chelmsford).

Dec. 7, 1905.

To the Board of Health of the Town of Chelmsford.

Gentlemen: — In response to a request, the State Board of Health has caused a well said to be used by the school children in the village of North Chelmsford to be examined by one of its engineers and a sample of the water to be analyzed.

The well is located in the thickly populated part of the village, where there are numerous possible sources of pollution at no great distance; and the results of the analysis show that the water has been highly polluted before entering the well.

In the opinion of the Board, the source cannot be regarded as a safe one from which to take water for drinking.

Dracut.

Aug. 3, 1905.

To the Water Commissioners of the Dracut Water Supply District, Mr. Stephen R. Kitchen, *Chairman.*

Gentlemen: — The State Board of Health has considered your application for advice as to the proposed plan of obtaining a water supply for the Dracut Water Supply District from the ground in the Goodhue

meadow so called, and has caused the locality to be examined by its engineer and samples of water from test wells driven in this meadow to be analyzed.

The results of the analyses show that, while the water is in most respects of good quality, it is affected by the presence of an excessive quantity of iron. The meadow is covered by a layer of peaty soil apparently about 3 feet in depth, and experience has shown that ground waters taken from beneath such soil are liable to be affected by an excessive quantity of iron, and in nearly every case in which water supplies have been taken from the ground under these conditions an excessive quantity of iron has appeared in the water after a longer or shorter period of use.

Regarding the quantity of water obtainable from wells at this place, the tests do not furnish definite evidence. They show that the soil is somewhat fine, and no considerable depth of very porous material was penetrated by the test wells. The quantity of water which was pumped from the test wells was small.

In view of the evidence furnished by these tests, it is doubtful, in the opinion of the Board, whether enough water could be obtained from wells in the Goodhue meadow to supply the quantity that will be required by the Dracut Water Supply District after water comes into general use; and the indications are that the water would be affected by an excessive quantity of iron, which would render it objectionable for many uses.

It is possible that more favorable conditions exist in other parts of the valley which have not thus far been examined; and the Board would advise, as the next step in your investigations, that you make a further examination of this valley, to determine whether more favorable conditions can be found in other parts of it, avoiding the portions covered with a considerable depth of peaty soil. The Board will assist you in these investigations by making the necessary analyses of the water, and will give you further advice as soon as the results of further tests are available.

Falmouth.

Dec. 7, 1905.

To the Board of Water Commissioners of the Town of Falmouth, Mr. John H. Crocker, *Chairman.*

Gentlemen: — The State Board of Health received from you on Oct. 23, 1905, the following communication requesting the advice of the Board as to the best method of preventing the pollution of the waters of Long Pond and safeguarding the water supply of the town: —

The water commissioners of the town of Falmouth, Mass., request the advice of the State Board of Health as to the best methods to adopt to prevent any possible contamination of the waters of Long Pond, the present source of supply for the town of Falmouth.

It is desired to safeguard the supply beyond criticism, and at the same time to interfere with the use of the pond and the property interests about it as little as may be.

In response to this application the Board has caused Long Pond and its surroundings to be examined by one of its engineers, and finds that at the present time there are only two dwelling houses near the pond: one being the engineer's house, located at the pumping station, the drainage from which is disposed of outside the water-shed of Long Pond; and the other a house near the northerly end of the pond, occupied only during the summer season, the drainage from which does not apparently reach the pond directly. The chief danger to the water supply at the present time is the use for picnic purposes in the summer season of the lands owned by the Trustees of Public Reservations and by the town on the easterly shore of the pond near its southerly end, and the use of the pond for boating and fishing; and, in the opinion of the Board, it is advisable for the town, in order to protect the purity of its source of water supply, to take police control of the pond and its shores by securing rules and regulations under the provisions of section 113 of chapter 75 of the Revised Laws, and enforcing them. The Board will make such rules and regulations as it deems necessary or desirable for the sanitary protection of this source of water supply, if you so request.

If it is desired to avoid restricting the present use of the pond and its shores as a public resort, it is probable that the town could obtain its supply of water from ground in the neighborhood of the pumping station, and discontinue the use of the pond. South of the pumping station the conditions for obtaining ground water near a chain of small ponds are apparently favorable; and if a good ground-water supply could be obtained here, the water would be better than that now obtained from Long Pond.

If you decide to make investigations with a view to obtaining a water supply from the ground, the Board will assist you, if you so request, by making the necessary analyses of samples of water, and will give you further advice when the results of investigations are available.

FITCHBURG.

JULY 1, 1905.

To the Board of Health of the City of Fitchburg, E. L. FISKE, M.D., *Chairman.*

GENTLEMEN: — In response to your communication received June 7, stating that many complaints were being made of the condition of the city water, the taste and odor of which was very objectionable, and asking that an investigation of the condition of the city water be made, the Board has caused the sources of supply to be examined and samples

of the water of the various reservoirs and the water being supplied to the city to be analyzed.

It appears that the complaints were first made on or about May 31, and that the objectionable taste and odor of the water reached its maximum about June 2 and disappeared about June 7, complaints being made from all parts of the city. Information furnished by the city water department shows that when the trouble occurred Meetinghouse Pond was not in use, and that water was being supplied from Marshall, Overlook and Falulah reservoirs. When the trouble occurred the water department changed the sources of supply, and supplied water to the city from Scott Reservoir through Falulah Reservoir.

The analyses of samples of water from Overlook, Scott and Falulah reservoirs show the presence of large numbers of organisms in the water of these reservoirs, including organisms of kinds which have been known to impart to the waters of ponds and reservoirs a disagreeable taste and odor, the more objectionable organisms being present in Overlook, although the numbers were small. While the difficulty had practically disappeared by the time the examination was made (June 9), and the cause of the trouble could not be definitely ascertained, it was very probably due, in the opinion of the Board, to the presence of microscopic organisms in the water of the reservoirs. The cause of the appearance and growth of such organisms in the waters of ponds and reservoirs is not known, nor is the Board able to advise you of any efficient and safe method of preventing the appearance of such organisms in your sources of water supply, or the disagreeable tastes and odors which they produce. It is not known that the use of water containing these organisms for drinking is injurious to health.

The waters of the various sources of water supply of Fitchburg have been similarly affected at previous times, but when all of the reservoirs are available it appears to be practicable usually to avoid supplying the city for a considerable length of time with water affected in this way; and such would doubtless have been the case at the present time, had it not been for the fact that, owing to necessary improvements near Meetinghouse Pond, the most important source of water supply of the city, that source was not available for use.

Judging from the records of analyses showing the quality of the water of the various reservoirs and the experience of past years, it will continue to be practicable, by observing frequently the appearance, taste and odor of the waters of the various reservoirs, to avoid the use of water seriously affected by organic growths or by taste and odor, excepting, possibly, on occasions such as the present, when one or more of the sources may for some reason not be available, or when, as may possibly happen, all of the reservoirs are more or less affected by organic growths; and a

continuation of the previous practice in the use of water seems likely to secure generally satisfactory results in the future, especially if, when a new supply is provided, — which will apparently soon be necessary, — a water of good quality shall be secured.

If the objectionable conditions should continue, the quality of the water supplied to the city can doubtless be made satisfactory by filtration.

Foxborough (State Hospital).

Oct. 5, 1905.

To the Trustees of the Foxborough State Hospital, **Charles E. Woodbury M.D.**, *Superintendent.*

Gentlemen: — In response to your request of September 16 for advice as to the quality of the water of two wells which were driven while the hospital was being built, with a view to their use as sources of water supply for the hospital, the Board has caused the wells and their surroundings to be examined by one of its engineers and a sample of the water to be analyzed.

The results of the examination show that this water has evidently been considerably polluted at some time, though at the present time it is being quite well purified before entering the wells.

On account of the nearness of sources of pollution, there is much danger that, if these wells should be used continually, the quality of the water would deteriorate; and, in the opinion of the Board, they cannot safely be used as sources of water supply for the hospital.

The conditions both east and west of the hospital appear to be favorable for obtaining water from the ground by means of wells; and it is possible that other tests at a greater distance from the hospital may show that suitable water can be obtained, and in sufficient quantity for all the requirements of this institution.

Gloucester (Y. M. C. A.).

Aug. 3, 1905.

To Mr. **Reuben Brooks**, *President, Young Men's Christian Association, Gloucester, Mass.*

Dear Sir: — In accordance with your request, the State Board of Health has caused a further examination to be made of the tubular well in the Y. M. C. A. building in Gloucester and a sample of the water to be analyzed; and finds that, while the water is somewhat less objectionable in quality than it was at the time the previous examination was made, it still contains an excessive quantity of chlorine and a much larger quantity of organic matter than is found in good well waters, and in the opinion of the Board it is unsuitable for drinking.

It would probably also be objectionable for use in boilers, but may reasonably be used to supply your tank and shower baths for bathing.

Gloucester (Well on Cole's Island).

Aug. 3, 1905.

To Mr. John C. Spring, *Gloucester, Mass.*

Dear Sir: — In response to your request of July 1 for an examination of the water of a well on Cole's Island, West Gloucester, used by several families as a source of water supply, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water is in most respects of good quality, but the quantity of organic matter present is larger than is found in good ground waters. The well is at present covered only with loose boards, and no provision has been made for preventing the entrance of surface water, and these conditions probably account for the excess of organic matter shown by the analysis. The water-shed of the well is used for pasturage, but contains no dwelling houses or other buildings.

If the well should be covered so as to exclude light and prevent the entrance of surface water, and cattle should be excluded from its neighborhood, water of good quality could doubtless be obtained from this source.

Great Barrington.

Sept. 7, 1905.

To the Committee on Water Supply and the Water Commissioners of the Great Barrington Fire District.

Gentlemen: — The State Board of Health received from you on Sept. 1, 1905, the following application requesting the approval by this Board of Goodale or Mount Washington Brook in the towns of Egremont and Mount Washington as a source of water supply for the Great Barrington Fire District, under the provisions of chapter 75 of the Revised Laws and chapter 245 of the Acts of the year 1902: —

The committee on water supply and the Board of Water Commissioners of the Great Barrington Fire District submit for your approval, as a source of water supply for the district, Goodale or Mount Washington Brook in the towns of Egremont and Mount Washington, draining a water-shed of about two square miles, and capable of being supplemented by water diverted by an intercepting canal from an adjacent water-shed of about one and three-quarters square miles.

The water made available from Goodale Brook may be further supplemented by appropriating the water of Fenton Brook in said town of Egremont when the latter is needed. It is proposed in the construction of works to make provision for ultimately utilizing all of these waters, as outlined in the plan and report of Percy M. Blake, C.E., dated Sept. 16, 1904.

Your approval of these sources of supply for the purposes of the district is respectfully requested.

The plan for a water supply for Great Barrington proposed by your engineer, Mr. Blake, in his report dated Sept. 16, 1904, provides for taking the water of Goodale Brook at a point in the town of Egremont about one and a quarter miles in a straight line above its junction with Fenton Brook, where the water-shed of Goodale Brook has an area of about two square miles, and for the construction of a storage reservoir at or near that point having a capacity of 24 million gallons. The plan of Mr. Blake further provides for supplementing the supply when necessary either by the construction of an additional storage reservoir on Goodale Brook of about the same capacity as the first (24 million gallons); or by diverting into Goodale Brook water draining from a water-shed of about one and three-quarters square miles tributary to Wright Brook; or by taking water from Fenton Brook, the water-shed of which is contiguous to that of Goodale Brook on the south; or by enlarging the supply in all of these ways, if necessary. Mr. Blake's plan also provides for improving the East Mountain Reservoir, and retaining it for further use.

The water of Goodale Brook is of good quality for the purposes of a public water supply, and the source can be protected from danger of serious pollution without special difficulty or expense. Water of good quality is obtainable also from the water-shed of Fenton Brook and the water-shed that would be tributary to the proposed intercepting canal in the valley of Wright Brook, and these water-sheds are at present uninhabited.

In the opinion of the Board, Goodale Brook, if a storage reservoir having a capacity of 24 million gallons should be constructed thereon near the proposed point of taking, would yield enough water for the present requirements of the Great Barrington Fire District, used in connection with the East Mountain Reservoir; but, in the opinion of the Board, the full yield of the source will be required in dry periods, and it will consequently be necessary that the dam and pipe line be constructed in the most thorough manner, otherwise a serious loss of water by leakage will result.

The Board hereby approves the use of Goodale Brook, developed as proposed in the report of Mr. Blake of Sept. 16, 1904, and as outlined herein, as a source of water supply for the Great Barrington Fire District, under the provisions of chapter 245 of the Acts of the year 1902.

The Board would advise that the reservoir be thoroughly prepared for the storage of water by the removal from the area to be flowed of all stumps, vegetable matter and peaty or loamy soil from which the water might take up organic matter. It is also desirable to lay a pipe through the reservoir to the stream at the upper end, in order that the reservoir

may be drawn off and cleaned if necessary, since reservoirs in such locations are apt to collect in time considerable quantities of solid matter washed down by the stream.

SEPT. 7, 1905.

To Mr. A. CHALKLEY COLLINS, *Chairman, Board of Water Commissioners, Great Barrington, Mass.*

DEAR SIR: — The State Board of Health received from you on Sept. 1, 1905, a communication addressed to its engineer, relative to its opinion of the further use of Green River as a source of water supply for the town of Great Barrington, the essential portion of which is the following: —

The committee on water supply, which had a conference with you at the State House last winter, understood you to say that you considered the continued use of water direct from Green River as a very possible source of danger to the public health, and that if the fire district did not take some action to improve its water supply the State Board of Health might see fit to publicly express its condemnation of the longer continued use of Green River. If, in your opinion, there is any objection from the standpoint of the public health to continuing our present system of pumping from the river, I think it is due to the voters of Great Barrington that you should distinctly say so, and then they can continue the present system if they see fit; but if, as many have understood, you think it is dangerous for us to continue the use of water direct from Green River, and your Board is likely to condemn such use if not discontinued in the immediate future, it seems to me that our citizens are entitled to know this at the present time, and before they take any action on the question at the meeting which is to be held on September 15.

Let us have the facts plainly and fully, regardless of consequences.

The opinion of the Board as to the quality of the water of Green River and as to the use of this stream as a source of water supply for Great Barrington was clearly stated in a communication of the Board to the Board of Water Commissioners of the Great Barrington Fire District under date of Oct. 5, 1899, which was published in the annual report of the State Board of Health for the year 1899, and also in Senate Document, No. 4, presented to the Legislature in January, 1900. That opinion is as follows: —

The water of Green River is nearly clear and colorless under ordinary conditions, but is harder than the water of the East Mountain Reservoir, and is turbid at times of high flow. The most serious objection to the use of this stream, however, is the population on the water-shed, by which the water is exposed to pollution by sewage; and under the circumstances the Green River must be considered an unsafe source from which to take water for drinking or other domestic purposes.

Green River above the point at which water is taken drains an area of about 52 square miles, of which 29 square miles are within the limits

of the State of Massachusetts, and the remainder — 23 square miles — in the State of New York. Within the portion of the drainage area in New York there are many dwelling houses and outbuildings, including three small villages located upon the banks of the stream and its tributaries, and the prevention of the pollution of the stream from these places is necessarily beyond the control of Massachusetts authorities. There are, also, more than 900 people living within the water-shed of Green River within the limits of Massachusetts. Under these circumstances the Board considers it impracticable to protect the Green River from pollution, and the Board regards the continued use of Green River as a constant menace to the health of the people of Great Barrington, and that the only practicable protection would be to have the water properly filtered.

SEPT. 14, 1905.

To the Board of Water Commissioners and the Committee on Water Supply of the Great Barrington Fire District.

GENTLEMEN: — The State Board of Health received from you on Sept. 13, 1905, the following communication, requesting advice as to the construction of the proposed works for taking water from Goodale Brook: —

> Referring to your approval of Goodale Brook as a source of water supply for the Great Barrington Fire District, under date of Sept. 7, 1905, which approval follows the plans of Percy M. Blake, C.E., date, Sept. 16, 1904, calling for a 50-foot dam, we desire further to ask your advice as to the construction of a 30-foot dam, with base on foundation constructed so as to admit, if it becomes necessary, of being raised to 50 feet; whether or not such construction would meet the approval of the State Board of Health.

The practice of constructing dams in the manner proposed is not uncommon, but the Board does not understand that the question of the engineering features comes within its province under the provisions of the act requiring the approval of the proposed sources of water supply. By constructing the dam of smaller height, the storage created on Goodale Brook will be about 10 million gallons instead of 24 million gallons obtainable by constructing the higher dam, and the capacity of the source in dry weather would consequently be less.

The quantity of water used in Great Barrington at the present time is thought to amount to 500,000 gallons per day, though this estimate does not appear to be based on very definite measurements of the quantity used. If the consumption of water is as great as it is said to be, a storage of 24 million gallons, or nearly that quantity, on Goodale Brook will be necessary in order to obtain an adequate supply of water for the present requirements of the district from that source alone, used in

conjunction with the present East Mountain Reservoir; but if one or the other, or both, of the auxiliary supplies — Wright Brook or Fenton Brook — should also be utilized, an adequate supply of water for present needs could be obtained with a smaller storage on Goodale Brook.

Your investigations have shown, moreover, that there are two available sites for storage reservoirs on Goodale Brook, and it may be of advantage to utilize both sites and build smaller reservoirs to secure the necessary storage, rather than to build a single larger reservoir in the beginning. Several methods are thus available and practicable in the development of a supply of water for Great Barrington from Goodale Brook, and it is not essential that the one requiring a 50-foot dam and a single storage reservoir of 24 million gallons be selected in the beginning.

When final plans of the works proposed for present construction have been prepared, the Board will, upon receipt of plans, advise you concerning them, if you so request.

Hadley.

May 12, 1905.

To the Board of Water Commissioners of the Town of Hadley.

Gentlemen: — The State Board of Health received from you on May 3, 1905, an application requesting the consent of the Board to the taking of Harts Brook, so called, above the State fish hatchery, and the approval of the location of a proposed dam and reservoir upon this stream, shown upon a plan submitted, under the provisions of chapter 146 of the Acts of the year 1905.

The Board has caused Harts Brook, the proposed source of supply, to be examined by one of its engineers and a sample of the water to be analyzed, and has examined the plans and other information submitted.

The water-shed of Harts Brook above the location of the proposed dam is uninhabited, and the water is of good quality for the purposes of a public water supply. The drainage area of the brook is not shown upon the plans, but the information furnished by the State map and by your measurements of the flow of the stream last year, taken in connection with the size of the proposed reservoir, indicates that a sufficient quantity of water for the present requirements of Hadley can probably be obtained from this source; and in case the yield should prove inadequate, there are other streams in the neighborhood from which an additional supply could be obtained if necessary.

The Board hereby consents to the use of Harts Brook as a source of water supply for Hadley at the point shown upon the plans submitted, and approves the location of the proposed dam and reservoir. The Board would suggest that the capacity of this reservoir, which is now estimated at 2,000,000 gallons, be made larger, if practicable.

HARDWICK (WHEELWRIGHT).

FEB. 2, 1905.

To MR. GEORGE W. WHEELWRIGHT, *President, George W. Wheelwright Paper Company, 95 Milk Street, Boston, Mass.*

DEAR SIR: — The State Board of Health has considered your request of Nov. 30, 1904, for an examination of the water of certain wells in the village of Wheelwright in the town of Hardwick, with reference to its use for drinking purposes, and has caused the wells and their surroundings to be examined and samples of the waters to be analyzed. It is understood that these wells are to be used temporarily as sources of drinking water in the village, until an adequate water supply suitable for drinking and other domestic purposes can be introduced.

The wells examined are numbered 1, 2, 3, 4 and 5, and are located on the northerly side of the village. Wells numbered 1, 2 and 5 are close to dwelling houses, and numbers 1 and 2 are quite close to the river. The results of the analyses show that all of the waters are affected somewhat by the population upon the territory near the wells. Wells numbered 3, 4 and 5 are affected in a much less degree than wells 1 and 2 at the present time. The water of well numbered 3 contains an excessive quantity of iron, which would make it objectionable for drinking and other domestic purposes.

In the opinion of the Board, wells numbered 4 and 5 may safely be used as sources of drinking water for the present; but the quality of these waters is likely to deteriorate after a considerable quantity of water has been drawn, and the water should be analyzed from time to time, so that the use of the wells may be discontinued if deterioration occurs. Provision should be made for introducing at as early a date as possible a supply of good water for the requirements of the village.

HOLDEN.

APRIL 6, 1905.

To the Water Commissioners of Holden, MR. HENRY W. WARREN, *Chairman.*

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to the use of Muschopauge Lake as a source of water supply for Holden, and has caused the proposed source and its surroundings to be examined, and has considered the plans of the works as outlined in the report submitted with your application.

It appears from this report that it is proposed to raise the level of Muschopauge Lake about 2 feet, and take water from the lake near its southeasterly end and supply it to Holden by gravity. Muschopauge Lake is now used as a source of water supply by the town of Rutland, but the quantity of water which the lake is capable of yielding under

present conditions is considerably in excess of the quantity required to supply the needs of both Rutland and Holden at the present time. If the lake should be raised, a slightly increased head would be obtained in Holden, and the lift of the pumps in the town of Rutland pumping station would be slightly reduced; but it would be necessary to clean thoroughly the area flowed by raising the lake, in order to prevent injury to the quality of the water. It does not appear that the extra storage is required, for the present at least; and, in the opinion of the Board, the question of raising the level of the lake should be postponed, and given a further consideration when a change in the level of the lake becomes necessary or desirable.

There are at the present time a few places on the water-shed from which it is possible that polluting matters might find their way into the lake; but by the enforcement of proper precautions the pollution of the lake from these places can be prevented. The water of the lake, as shown by numerous analyses, is nearly colorless, soft, and otherwise of good quality for the purposes of a public water supply; and, in the opinion of the Board, Muschopauge Lake is an appropriate source of water supply for the town of Holden.

Holyoke (Chemical Paper Company).

July 6, 1905.

To the Board of Health of the City of Holyoke.

Gentlemen: — In accordance with your request of June 21, 1905, the State Board of Health has caused a driven well located on the premises of the Chemical Paper Company in Holyoke to be examined and a sample of the water to be analyzed.

The analysis shows that the water of this well resembles that of other wells situated near the canals in Holyoke. The water of this well has at some time been considerably polluted, though subsequently partially purified in its passage through the ground before entering the well. The quantity of organic matter present in the water is larger than is found in good ground waters, and the number of bacteria is high, and the Board cannot recommend its use for drinking.

Holyoke (American Writing Paper Company).

Oct. 5, 1905.

To the American Writing Paper Company, Department of Manufacturing and Maintenance, Holyoke, Mass.

Gentlemen: — In accordance with your request, the State Board of Health has caused an examination to be made of a well at the George R. Dickinson Paper Company's mill in Holyoke and a sample of the water to be analyzed, and finds that this water is not safe for drinking.

Holyoke (Well in Germania Park).

Oct. 5, 1905.

To the Board of Park Commissioners of the City of Holyoke, Mr. Daniel J. Hartnett, *Secretary.*

Gentlemen: — In response to your request, the State Board of Health has examined the water from the well in Germania Park at the corner of Park and Jackson streets in Holyoke, and finds that the water is badly polluted, and would advise that its further use be discontinued.

Holyoke (Wells).

Oct. 5, 1905.

To the Board of Health of the City of Holyoke.

Gentlemen: — In accordance with your request, the Board has caused an examination to be made of wells at the Holyoke Warp Company, the Newton Paper Company and the Gill Paper Company, all of which are situated in the thickly built-up part of Holyoke, and has caused samples of the waters of these wells to be analyzed.

The water of the well at the Holyoke Warp Company has been considerably polluted, and, while it has been fairly well purified in its passage through the ground before entering the well, the water is objectionably hard, and the Board cannot recommend its use for drinking.

The waters of the wells at the Newton Paper Company and the Gill Paper Company are evidently derived very largely by filtration from the canals. The canal water is badly polluted by sewage, and it is evident from the analyses that the water has not been thoroughly purified in its passage through the ground before entering the wells. Under the circumstances, the Board regards these wells as unsafe sources of drinking water.

Lawrence.

May 15, 1905.

To the Lawrence Water Board, Lawrence, Mass.

Gentlemen: — The State Board of Health has considered your application for advice as to an additional water supply to be taken from wells in the valley of a tributary of the Shawsheen River in Andover, which enters the river from the west at Frye Village, and has caused the locality to be examined by its engineer and samples of the water from several test wells recently driven in this valley to be analyzed.

Nearly all of the test wells were driven into coarse gravel, at depths ranging from 27 to 43 feet, after passing through a layer of peat in most places from 4 to 17 feet in depth, and layers of fine and course sand. The water flowed naturally from these wells at a height of about 1 foot above the ground, and could be pumped freely from most of the

wells. The water from some of the wells contained an excessive quantity of iron, but the water from the greater number was clear, colorless and odorless, and contained but little iron or organic matter.

The water-shed in which these wells are located has a total area of a little over 1 square mile, but in a part of the valley draining chiefly toward a small tributary of the main stream there are several groups of farm buildings with cultivated lands about them which would pollute the water; and there is a considerable depth of peaty soil near the point where this tributary joins the main stream. In locating wells in this valley it will be necessary to avoid drawing polluted water and water which would be affected by an excessive quantity of organic matter or iron, and the circumstances are such that it would be necessary to exclude the water-shed of the tributary stream. It would be practicable, however, to extend the wells or works for collecting ground water much farther down the valley on the northerly side of the main stream, where the conditions for obtaining ground water are favorable, provided the wells should be located at a sufficient distance from the stream, probably at least 100 feet, to avoid the entrance of polluted water therefrom.

By excluding the areas which would furnish objectionable water and including all of the available area from which good water could be obtained, it is probable that a water-shed of about two-thirds of a square mile could be made available for furnishing unpolluted water. Assuming that the wells or collecting works would be extended widely through this area, so as to make available all of the water stored in the ground so far as practicable, and assuming that the depth and porosity of the soil throughout the area would be found upon further tests to be as favorable as at the more favorable places from which ground water is drawn for the supply of other cities and towns in the State, wells or other works for collecting unpolluted water in this valley could not be depended upon to yield more than about 300,000 gallons per day.

An examination of the water-shed shows that it is surrounded by ledges on the northerly, westerly and southwesterly sides; and it is improbable that by pumping water from the ground in this valley water would be induced to flow from beyond the superficial limits of the water-shed.

An examination of the heights of water in your distributing reservoir shows that the loss of water from the reservoir for periods ranging from 55 to 70 days in the last two winters has averaged about 500,000 gallons per day. The consumption of water in Lawrence has been reduced probably lower than that in any other city in the State, and there is no likelihood that a further reduction in the use of water per inhabitant can be effected. The city is growing rapidly, and even if the consumption per inhabitant remains as at present, the actual quan-

tity of water used must increase; and it is essential, in order to avoid the danger of the necessity of using unfiltered Merrimack River water, that a source should be secured which is capable of furnishing much more than 500,000 gallons per day. The quantity of unpolluted water obtainable from the valley in which the test wells are located at Andover is unlikely to supply more than half the quantity required to tide the city over the coming winter.

As already stated, the water of most of the test wells is clear, colorless and odorless, and free from organic matter; but it contains a large quantity of carbonic acid, which would cause it to take up lead in large quantities if delivered through lead service pipes. It appears that about 70 per cent. of the service pipes of the city of Lawrence are of lead or are lined with lead; and the ground water from the valley in Andover could not be introduced into the distributing system of the city without jeopardizing the health of those to whom it would be supplied through lead service pipes. In the city of Lowell, where the service pipes are also of lead, many cases of lead poisoning resulted from the use of such a water; and it became necessary to abandon the use of the wells in the valley of River Meadow Brook, from which this water was supplied.

If the water from the wells in Andover should be pumped through an independent pipe into the distributing reservoir, the trouble from this cause might be less; but ground water, as is well known, deteriorates rapidly when stored in an open reservoir, and becomes offensive, so that objectionable conditions would result, in addition to the danger of lead poisoning.

With these conditions existing, the Board cannot recommend the use of water from the valley in Andover, in which the test wells are located, as an additional water supply for the city of Lawrence.

June 5, 1905.

To the Committee on Water Supply of the City of Lawrence.

Gentlemen: — I have the honor to acknowledge the receipt of your communication of June 1, requesting this Board to send a representative to Lawrence for the purpose of explaining the analyses of the water taken from wells in the vicinity of Frye Village; and requesting, further, a comparison of the analyses with ten or more water supplies approved by this Board, to show especially how the quantity of carbonic acid shown by the analyses recently sent to you compares with that of other waters used for domestic purposes.

In reply, the Board directs me to inform you that the results of the analyses of the water of the wells near Frye Village in Andover recently sent you at your request are interpreted in all essential features in the reply of this Board of May 15 to your application for advice with reference to the use of wells in that locality as sources of water supply, and

that the Board deems the sending of a representative to make further explanation of these analyses unnecessary. If you wish to compare the results of these analyses with the analyses of other waters used as public water supplies in this State, such comparison may be made at the office of the Board, where the analyses are kept on file.

In your communication you request also an examination of the water of the wells now being driven on the north bank of the Merrimack River, opposite Pine Island in the town of Methuen, and advice as to the use of water from this locality. The Board will make the necessary examinations and advise you as promptly as practicable.

JUNE 16, 1905.

To the Committee on Water Supply of the City of Lawrence, MR. CORNELIUS J. CORCORAN, *City Clerk.*

GENTLEMEN: — In accordance with your request, dated June 1, 1905, for an examination of the water of wells on the north bank of the Merrimack River, opposite Pine Island in the town of Methuen, the Board has caused the locality to be examined and samples of the water of the test wells to be analyzed.

The character of the soil in which the wells are driven shows much variation from place to place, but in the majority of the wells a porous stratum was found from which water could be pumped freely in considerable quantity. The area containing porous soil in this locality is evidently not very extensive, and the quantity of water obtainable from wells at this place would depend very largely upon the freedom with which water from the river would filter through the ground to the wells, — an element which can only be determined by trial. If water from the river should pass freely into the ground, when the ground water is lowered below the river level enough water could doubtless be obtained from the ground in this locality to supply the present needs of the city when used in connection with the present city filter.

Analyses of samples of the water from several of the wells show that the water of most of them contained at this time such an excessive quantity of iron as would make it objectionable for many domestic purposes; but the samples contained considerable sand or silt, and it is probable that if the wells should be pumped until clear water was obtained the quantity of iron would decrease. The quantity of chlorine and nitrates present was also high, indicating previous pollution; but the most objectionable feature of the analyses is the large quantity of carbonic acid present in the water, the quantity being greater than was found in the water of the wells near Frye Village. The use of such a water supplied through lead service pipes for drinking would cause lead poisoning.

The samples thus far collected from the wells probably represent the natural ground water of the region flowing toward the river. If, by pumping from the wells in this locality and lowering the ground water below the level of the river, water should filter freely into the ground from the river, it is probable that the character of the water of the wells would undergo considerable change. Whether the quantity of carbonic acid would then become such that the water might safely be used for drinking after passing through lead pipes can only be determined by means of a thorough test. In order to make such a test, a considerable number of wells should be put in and water pumped from them at such a rate as would be necessary in order to obtain an adequate auxiliary supply of water for Lawrence, and for a sufficient length of time to determine the probable quality of the water under continuous use. Such a test would probably require pumping for a period of at least two weeks, and possibly for a much longer time.

There are indications that water might be obtained from wells on the south bank of the river near the large bend in the stream below Pine Island, considerably nearer the city. It is understood that tests have been made on the south side of the river above South Lawrence as far up stream as a point approximately opposite Glen Forest, so called, with unfavorable results, but it does not appear that tests have been made above this point. It is important that a suitable additional supply of water for the city be secured with as little delay as possible; and the Board would advise, as the next step in your investigations, that you make tests of the ground by means of wells along the south side of the river between a point opposite Glen Forest and the lower end of Pine Island. The wells should be located at least 100 feet from the river and approximately 300 to 400 feet apart, as in the case of the tests recently made.

Upon notification of the beginning of such tests the Board will examine the results as they are obtained and make the necessary analyses of samples of water from the test wells, and will then advise you as to further investigations.

AUG. 22, 1905.

To the Committee on Water Supply of the City of Lawrence.

GENTLEMEN: — The State Board of Health received from you on Aug. 18, 1905, the following communication relative to a proposed additional water supply for the city of Lawrence: —

At a meeting of the special committee on water supply, held Aug. 16, 1905, it was voted to ask your Honorable Board if it would approve of connecting up the driven wells at the Griffin farm on the Lowell road to the extent of 1,000,000 gallons daily, and pumping the same directly into the reservoir.

These wells were examined in accordance with the request of your committee last June, with a view to the use of the water from this locality as an auxiliary supply for the city of Lawrence; and it was found that the water contained at that time such an excessive quantity of carbonic acid that if supplied through lead service pipes for drinking it would cause lead poisoning; and the Board further advised as follows: —

The samples thus far collected from the wells probably represent the natural ground water of the region flowing toward the river. If, by pumping from the wells in this locality and lowering the ground water below the level of the river, water should filter freely into the ground from the river, it is probable that the character of the water of the wells would undergo considerable change. Whether the quantity of carbonic acid would then become such that the water might safely be used for drinking after passing through lead pipes can only be determined by means of a thorough test. In order to make such a test, a considerable number of wells should be put in and water pumped from them at such a rate as would be necessary in order to obtain an adequate auxiliary supply of water for Lawrence, and for a sufficient length of time to determine the probable quality of the water under continuous use. Such a test would probably require pumping for a period of at least two weeks, and possibly for a much longer time.

It does not appear that the further test suggested in the above communication has yet been made, and the only evidence available as to the character of the water in these wells indicates that if the water should be introduced into the reservoir of the Lawrence water works it would cause lead poisoning.

Under the circumstances, the Board cannot approve the pumping of water from these wells into your reservoir at the present time. If, after a pumping test such as that indicated, a sufficient quantity of water should be obtained, and the quality of the water should be shown to be as satisfactory as the present filtered water in respect to the quantity of carbonic acid present and in other respects, then this water could be used.

If such a test is to be made, it should be begun without delay and carried on as rapidly as possible, in order that some other provision for securing an adequate water supply for the city may be made before the beginning of winter, in case it shall be found impracticable to secure enough water of suitable quality from wells in the locality indicated.

Oct. 25, 1905.

To the Committee on Water Supply of the City of Lawrence.

Gentlemen: — The State Board of Health received from you on Sept. 11, 1905, the following communication requesting its advice as to the use of water from the ground near the north bank of the Merrimack River in the westerly part of the town of Methuen as an additional water supply for the city of Lawrence: —

I am instructed by the committee on water supply to notify your Honorable Board that in compliance with an order of the city council, passed September 7, work has been commenced on the driven wells at the Griffin farm, on the north bank of the Merrimack River in Methuen, Mass. It is proposed to connect these wells and pump them for the period suggested, about two weeks. The committee would be pleased to have you, if convenient, send a suitable person to mark the progress of the work, and take tests when it was thought necessary.

Subsequently twenty test wells were put in near the Griffin farm in the locality indicated, and connected with a steam pump; and a pumping test was made by pumping continuously from these wells from October 4 until October 18, the rate of pumping maintained during this period being a little over 500,000 gallons per day, according to the records kept by the water department. The wells are located in a line approximately parallel with the Merrimack River and about 100 feet distant therefrom, and the distance between the extreme wells is about 720 feet. Other wells were put in, which furnished an opportunity to note the effect of the pumping on the level of the ground water. Samples of water were collected under the direction of the Board at frequent intervals during the test.

The Board has considered the information submitted as to the quantity of water pumped, the variations in the height of the water in the observation wells and in the river near by, and has examined the results of the numerous analyses of the water from the test wells made during the progress of the test and analyses of the city water at this and previous times.

The object of this test has been to determine not only whether it is practicable to obtain enough good water here to supply the additional requirements of Lawrence above the capacity of the present filter in cold weather, but also to determine whether the water, after mixture with the city water, could be used with safety when drawn through lead service pipes, — previous tests of wells at this place having shown the presence of so large a quantity of carbonic acid that the use of the water in connection with the use of the present city water would be likely to cause lead poisoning.

As to the practicability of obtaining enough water from this source for the additional requirements of Lawrence above the capacity of the present filter, the results of the test are unfavorable. The water in the ground about the wells and for a long distance on the landward side thereof went down rapidly throughout the test; and the observations, so far as they go, do not indicate that river water was filtering into the ground during this test in such quantity that the rate of pumping could have been maintained from these wells for a very considerable time longer, — making it doubtful whether enough water for the addi-

tional requirements of the city could be obtained from wells in this locality unless possibly by the construction of extensive collecting works.

An examination of the results of the analyses made during the recent test shows that the water in most respects was of good quality, but that the quantity of carbonic acid was high in the beginning and did not diminish as the test proceeded, remaining at the end slightly higher than at the beginning. This quantity is such that, if enough of this water should be introduced into the reservoir or distributing system of the city of Lawrence to supply the city adequately at all times, the water would be likely to take up enough lead from the lead service pipes of the city to cause lead poisoning; and the Board does not advise the introduction of this water into the reservoir or supply mains of the city of Lawrence.

Leicester.

Aug. 3, 1905.

To the Board of Water Commissioners of the Leicester Water Supply District, Mr. H. O. Smith, *Chairman.*

Gentlemen: — The State Board of Health received from you on July 20, 1905, the following application requesting approval of the purchase of water by the Leicester Water Supply District from the city of Worcester to meet the present emergency, the yield of the sources of water supply of the district having become inadequate: —

The water commissioners of the Leicester Water Supply District hereby make application to your Honorable Board, as provided by chapter 361 of the Acts of 1902, for your approval of the water of the city of Worcester as a proper source of water supply for said district in a case of emergency, as provided in said chapter.

It is evident from the investigation of the Board that the present sources of water supply of the district are incapable of furnishing enough water for its requirements in dry weather, and that an emergency now exists, requiring that an additional quantity of water be obtained without delay from some suitable source.

It is practicable to obtain water for a part of the district, lying chiefly in Cherry valley, from the works of the city of Worcester; and it is possible that, if a supply should be furnished by the city to this portion of the district, the present sources would furnish a sufficient quantity of water for the remaining portions. There appears to the Board to be no other way of securing a supply of suitable water to meet the present emergency with as little delay as by connecting with the works of the city of Worcester; and the Board hereby approves the use by the district of water from the Worcester water works, under the provisions of chapter 361 of the Acts of the year 1902.

The act of 1902 provides that a temporary supply obtained in this way shall not be used for more than six months in any one year; and, since the sources of water supply of the Leicester Water Supply District are evidently inadequate for the requirements of the district in the drier portion of nearly every year, the Board would advise that investigations be begun without delay, with a view to securing a supply of good water adequate for the requirements of the district at all times.

Lynn (J. B. Renton Company).

April 6, 1905.

To the J. B. Renton Company, Lynn, Mass.

Gentlemen: — In response to your request for an examination of the water of a tubular well at your factory, and advice as to whether the water is suitable for drinking, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The well is located in a densely populated part of the city, not far from the harbor. The water, while nearly clear, colorless and free from odor, is very hard, has evidently been badly polluted, and contains a large number of bacteria. In the opinion of the Board, this water is unsafe for drinking; and if it is to be used in the factory, it should be supplied in such a manner that it will not be accessible for drinking.

Medford (Medford Boat Club).

Oct. 5, 1905.

To the Medford Boat Club, Medford, Mass.

Gentlemen: — In response to your request for an examination of the water of a filter used for the purification of Mystic Lake water for the use of your members and the public in general, the State Board of Health has caused samples of the water before and after filtration to be analyzed.

The results of the examination show that the filtration is not efficient, considerable numbers of bacteria being present in the filtered water, some of them of kinds characteristic of sewage. The water can be efficiently filtered and made safe for drinking by passing it through a filter of sand 5 feet in depth. Such a filter may be seen in use at the State House.

Mendon (Well at Schoolhouse).

July 6, 1905.

To the Board of Health of the Town of Mendon.

Gentlemen: — In response to a request of the superintendent of schools, the State Board of Health has caused an examination to be made of the well used to supply the public school located on Main Street,

north of the Milford road in Mendon, and has caused a sample of the water of the well to be analyzed.

The results of the analysis show that the water is very badly polluted, and is unsafe for drinking. The Board would advise that the further use of water from this well be prevented, and that a new source of water supply be provided for the use of the school.

Methuen.

Dec. 7, 1905.

To the Board of Water Commissioners of the Town of Methuen, Mr. Henry Arnold, *Chairman.*

Gentlemen: — The State Board of Health received from you on Nov. 11, 1905, an application for advice with reference to a proposed additional water supply for Methuen, to be taken from Harris Pond, the water from which can be conveyed to the present pumping station by gravity.

In response to this application, the Board has caused the proposed source of supply to be examined by its engineer and a sample of the water to be analyzed, and has considered the information available as to the quality and quantity of water obtainable from the present works and the probable requirements of the town as to water supply in the immediate future.

The quantity of water furnished by your present sources of supply appears thus far to have been sufficient for the requirements of the town; but long hours of pumping are required to maintain the supply in the drier portion of the year, and it is doubtful whether enough water for all the requirements of the town could be obtained from these sources in a very dry season. The town is growing rapidly, and it is important, in the opinion of the Board, that an additional supply of water be made available without delay.

The quality of the water of the present sources does not appear to be objectionable at present, but the quantity of iron has increased rapidly within the past two years, and, if this deterioration should continue, the water will soon become objectionable for many domestic purposes; and, in selecting a new source of supply, allowance should be made for the possible necessity of reducing the draft from the present sources or discontinuing the use of some of the wells, in order to prevent further deterioration in the quality of the water.

The water of Harris Pond, the proposed source of additional supply, judging from the results of the two analyses of this water which are available, has but little color and is in other respects naturally of good quality for a surface water; but the water when examined had a vegetable

odor, and if this source should be used it is probable that, while the water would usually be of satisfactory quality, there would be times when the water would be affected by disagreeable tastes and odors, on account of the presence of microscopic organisms.

The water-shed of Harris Pond is small, its area, exclusive of the pond, being but little over a quarter of a square mile, and the quantity of water which this source would yield in a very dry season would be much less than the quantity now drawn from your present sources; so that the use of this source would not add very materially to the capacity of your works, and there does not appear to be any other surface-water source in this region that is available for a further supplementary supply.

An examination of the region about your present sources of supply shows that it may be practicable, by extending the wells farther up the valley of the brook leading from Harris Pond, to secure a large additional quantity of ground water, since the conditions appear to be more favorable farther up the valley for obtaining water from the ground than they are in the immediate neighborhood of your present wells. It is also possible that an additional quantity of ground water could be obtained from the neighborhood of the Spicket River, above the brook flowing from Harris Pond.

A good ground water would be of much more satisfactory quality than the water of Harris Pond; and, considering the circumstances, the Board does not at present advise the taking of water from Harris Pond, but would advise that you make further investigations, with a view to securing an additional supply of ground water in the region about your present works. The Board would suggest that investigations be made first in the valley of the brook flowing from Harris Pond, and that test wells be driven at various points in this valley, if necessary up to the highway crossing above the pumping station. If the conditions are not found to be favorable for obtaining water freely from the ground there, further tests should be made in the valley of the Spicket River, above your present wells.

These investigations should be made under the direction of an engineer of experience in matters relating to ground-water supplies; and the Board will assist you, if you so request, by making the necessary analyses of samples of water, and will give you further advice when the results of further tests are presented.

Milton (Leopold Morse Home).

Feb. 2, 1905.

To Mr. Solomon Schindler, *Superintendent, Leopold Morse Home, Mattapan, Mass.*

Dear Sir: — In response to your request of Jan. 3, 1905, the Board has caused a well located on the grounds of the home to be examined, with a view to its possible use as a source of water supply for domestic purposes.

The examination shows that there are sources of pollution at no great distance from the well, and the results of an analysis of a sample of water collected recently show that the water is hard, and has been at some time badly polluted. In the opinion of the Board, the water is unsafe for drinking at the present time.

Nashawena Island (Proposed State Prison).

Oct. 5, 1905.

His Excellency William L. Douglas, *Governor.*

Sir: — The State Board of Health received from you on Sept. 13, 1905, the following application for advice relative to the water supply and climatic conditions of Nashawena Island, with a view to its use as a location for a branch State Prison: —

Ordered, That the State Board of Health is hereby requested to make an investigation of the water supply on Nashawena Island, and to report to the Governor and Council at as early a date as possible the opinion of the Board relative to the quantity and quality of said water supply; and the Board is also requested to embody in such report a statement as to the climatic conditions and such other features of the island as may properly be considered by the Board in view of the provisions of chapter 106 of the Resolves of the year 1905.

The Board has visited and examined Nashawena Island and has caused samples of waters found there to be analyzed, and has considered the probable quantity and quality of water obtainable.

As a result of its examination, the Board finds that the surface waters of the island are as a rule highly colored, and contain an excessive quantity of organic matter. The water of a natural pond known as Ten Acre Pond, located a little west of the central portion of the island, has less color and contains less organic matter than the others; and an examination of this source shows that the quality of the water can be improved by draining the swamps on the water-shed of the pond and by cleaning the bottom of the pond. It also appears to be practicable to raise the level of the pond by building a dam near its outlet; and it is possible that enough water for the reasonable requirements of 1,200 or 1,500 persons could be obtained from this water-shed.

It is also evident from this examination that a considerable quantity of water can be obtained from springs in the easterly end of the island, and enough good water for drinking and cooking purposes in the proposed institution can be obtained from the ground in this region; but a further investigation will be necessary before a definite estimate of the quantity of spring and ground water obtainable here can be made.

While the limited investigations made by the Board show that enough water for all the requirements of a population of 1,200 to 1,500 can be obtained, the best method of developing a water supply and of protecting it from pollution must receive further careful consideration, and should be investigated before locations for buildings are determined upon; otherwise, the difficulty and cost of securing a proper water supply may be very serious.

There are numerous small swampy areas, especially toward the westerly end of the island, which can apparently be drained without difficulty; and all such areas should be drained before the island is occupied by large numbers of people.

While no meteorological records appear to have been kept at this island, the Board has no reason to believe that the climate of Nashawena differs materially from that of the other islands in this region or the mainland near by.

Newburyport.

Dec. 7, 1905.

To the Board of Health of the City of Newburyport.

Gentlemen: — The State Board of Health received from you on Nov. 4, 1905, a communication requesting an examination of the water supply of the city, and advice as to the best method of overcoming its disagreeable taste and smell; and in response to this request the Board has caused the source of supply to be examined by its engineer and samples of its water to be analyzed.

The water supply of Newburyport is drawn in part from a group of large covered wells and in part from an open basin which receives the flow of several springs, including the Jackman Spring, so called. During the past summer four deep tubular wells have been bored in the valley of the main feeder of this basin, and at the present time water from these wells is being pumped into the basin. The water of the large wells is of good quality, and is apparently free from taste and odor. The water of the tubular wells, which is discharged into the open basin, contains an excessive quantity of iron, which causes the water to have a disagreeable taste and appearance, though this water was free from odor when examined. The water of the open basin has an unpleasant odor, and contains a much larger quantity of organic matter than the water of the wells or of the Jackman Spring, showing a considerable deteriora-

tion of these waters after entering the open basin. It is a well-known fact that ground waters deteriorate rapidly in quality when exposed to light in an open basin such as this, and become affected by organic growths; and the objectionable taste and odor of the Newburyport water is no doubt due mainly to this cause.

If the water of the tubular wells and Jackman Spring should be discharged into the large wells, or conveyed directly to the pumping station and thence supplied to the city, the deterioration of the water could be prevented; but, owing to the large quantity of iron in the water of the tubular wells recently driven, it is probable that the water would still be unsatisfactory for some domestic uses. Moreover, the consumption of water in Newburyport at the present time is evidently in excess of the capacity of the present works in a dry season, and it is impracticable to avoid the use of the water of the open basin unless an additional source of supply shall be introduced.

Under the circumstances, the Board would recommend that measures be taken without delay to provide a sufficient additional supply, so that the use of the objectionable water from the open basin and from the wells containing the excessive quantity of iron may be avoided.

Northampton (Mt. Tom Sulphite Pulp Company).

July 6, 1905.

To the Mt. Tom Sulphite Pulp Company, Mt. Tom, Mass.

Gentlemen: — A further examination has been made by the State Board of Health of the wells of the Mt. Tom Sulphite Pulp Company, in accordance with your request of Dec. 2, 1904, and several samples of water collected from the wells since that date have been analyzed.

These analyses show that the water of the wells has at some time been considerably polluted, and, though subsequently purified to a considerable extent in its passage through the ground before entering the wells, the quantity of organic and mineral matters present is larger than is found in good ground waters. There has been a considerable deterioration in its quality since the wells were first used, and the quantity of manganese present is still very large.

While, in the opinion of the Board, the water is probably safe for drinking at the present time, it is very hard, and is not a desirable drinking water; and, as its quality is deteriorating, it is important that it should be analyzed from time to time, and its use discontinued if necessary.

Northborough.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on May 4, 1905, for preventing the pollution and securing the sanitary protection of the waters of Cold Harbor Brook and its tributaries, used by the town of Northborough as a source of water supply.

Northbridge (Rockdale).

July 6, 1905.

To the Paul Whitin Manufacturing Company, Northbridge, Mass., **Mr. Paul Whitin**, *Assistant Treasurer.*

Gentlemen: — The State Board of Health received from you on June 1, 1905, an application for advice with reference to a proposed additional water supply for the village of Rockdale, to be taken from wells on the westerly side of the Blackstone River, southwest of the village, and has caused the locality to be examined by one of its engineers and samples of the water of a test well at the locality indicated to be analyzed.

The test well from which the samples were collected is located in a gravel bank, about 250 feet from an arm of the Blackstone River and 400 feet from the nearest house in the village; and, judging from the character of the soil about the well and the results of a pumping test when water was drawn from the well for several days at the rate of 1,500 gallons per hour, enough water for the requirements of the village can be obtained from the ground at this place by means of a system of tubular wells, as proposed.

Analyses of the water indicate that some of the water entering the well had been polluted, but subsequently purified in its passage through the ground, and in its present condition the water is of good quality for the purposes of a public water supply. There are sources of pollution at no great distance from this well, and if a large quantity of water should be pumped continuously from a well or wells at this place the quality might deteriorate and the water be affected by sewage discharged into the ground from buildings in the village or by water filtering through the ground from the Blackstone River.

In the opinion of the Board, if wells had been located in the low land on the opposite side of the gravel ridge, southwest of the test well, where the conditions for obtaining water freely from the ground appear to be favorable, the danger of deterioration in the quality of the water would have been much less; but the indications are that a well or a system of wells near the test well will continue to yield good water if the quantity

drawn from the ground shall not be more than is necessary for the requirements of the present village.

If it shall be decided to take water from the ground at the location of the test well, the Board would advise that the water be analyzed from time to time during the drier portion of the year, when the greatest quantity of water is being drawn from the wells, in order that any change in the quality of the water may be detected.

Norwell (Well in District No. 6).

Nov. 2, 1905.

To the Board of Health of the Town of Norwell, Dr. H. J. Little, *Chairman.*

Gentlemen: — In response to your request of Sept. 26, 1905, for an examination of the water of the well on the premises of Albert J. Lovett, which, you state, is used by the pupils of District No. 6 as a source of drinking water, the State Board of Health has caused the well and its surroundings to be examined and a sample of its water to be analyzed.

The results of the analysis show that the water is grossly polluted. The well is located within a few feet of a barn, in which several cows are kept, the cellar of which is used as a pigpen, while the corner nearest the well is used as a privy. The bottom of the well is lower than that of the barn cellar, and drainage from the cellar evidently finds its way into the well.

The Board would recommend that the further use of this well as a source of drinking-water supply be prevented.

Norwood.

May 4, 1905.

To the Board of Water Commissioners of the Town of Norwood.

Gentlemen: — The State Board of Health received from you on Dec. 17, 1904, the following application for advice with reference to the quality of the water supply of the town of Norwood: —

> We would like to have you make an analysis of the town of Norwood's water, for the purpose of finding out if there is anything in the water that would be injurious to the health of the water takers of the town.

It appears that the water takers of Norwood are supplied with water from the public works through lead service pipes, and the Board has directed its investigations to determine whether the water acts upon lead to such an extent that it is likely to injure the health of those who use it for drinking. For this purpose samples of water have been collected from dwelling houses in different parts of the town, and the quantity of lead present has been determined.

The results of the analyses show that the water contains an excessive quantity of lead, which is evidently taken up in its passage through the lead service pipes through which it is supplied from the street mains and distributed in the houses. Examinations of the water of Buckmaster Pond show that it contains an excessive quantity of carbonic acid, which acts upon the lead of the pipes, forming a poison which slowly accumulates in the human body with very serious results. Surface waters do not, as a rule, take up great quantities of lead from lead service pipes; and the analyses of the Norwood water in 1898 do not show that its action upon lead pipe at that time differed materially from that of other surface waters. The cause of the great increase in the action of this water upon lead pipe is not known, though it may be due to drawing the pond to a much lower level than was the case in 1898, thus causing the inflow of an unusual quantity of ground water containing carbonic acid, which is the principal cause of the action of the water upon lead.

The examinations made by the Board show that the water now supplied to Norwood cannot be conveyed into and distributed about the houses of the town through lead pipes without danger that it will greatly injure the health of those by whom it may be used; and, in the opinion of the Board, it is necessary, in order to preserve the health of the people of the town, either to replace the lead pipes with pipes of some other material which will not be acted upon by the water, or if acted upon will not cause injury to the health of those who use the water for drinking, or to take water from another source which will not act upon lead pipe. The Board would recommend that one or the other of these plans for preventing injury to the health of the people of Norwood be carried out without delay.

Palmer.

June 29, 1905.

To the Board of Health of the Town of Palmer.

Gentlemen: — In accordance with the request contained in your communication of June 9, stating that many complaints were being made of the quality of the water supplied to the village of Palmer by the Palmer Water Company, and asking the advice of this Board as to its quality, the Board has caused the sources of supply to be examined by one of its engineers and samples of the water to be analyzed.

The results of the analyses of the water show the presence of considerable numbers of microscopic organisms of kinds which have been known to impart disagreeable tastes and odors to the water of ponds and reservoirs, and the objectionable taste and odor of the water supplied to Palmer is doubtless due to the presence of these organisms. It is not

known that water containing such organisms would be injurious to health if used for drinking.

The records of previous analyses and examinations of the water supplied to Palmer show that such organisms have been present in considerable numbers in other years. The cause of the presence of these organisms is not known, nor is the Board able to advise you of a practicable and safe method of preventing their presence in the water and the disagreeable tastes and odors which they produce. It is probable, however, that by thoroughly cleaning the bottoms of the reservoirs and removing all organic matter therefrom a considerable improvement could be effected in the quality of the water.

The information available to the Board as to the capacity of the sources of water supply of Palmer indicates that the use of water in the village already exceeds the capacity of the sources in a dry season, and that an additional supply is necessary. The Board would advise that an investigation be made without delay, relative to improving and enlarging the water supply of the village.

Peabody.

April 6, 1905.

To the Committee on Water Supply of the Town of Peabody, Mr. H. F. Walker, *Chairman.*

Gentlemen: — The State Board of Health received from you on Feb. 7, 1905, the following application for advice with reference to a proposed additional water supply for the town of Peabody: —

The water committee of the town of Peabody, realizing the necessity for an additional supply, are considering making application to the Legislature for rights to take water from Middleton, Boston and Fish brooks, situated in the towns of Middleton, North Andover and Boxford.

In utilizing these brooks it is our idea that a pipe line would be constructed to Suntaug Lake, which for the immediate present would serve the needs of Peabody; and that in future an extension would be made to the water-sheds of the above-named brooks, intercepting these water courses at the feasible point nearest to their junction with the Ipswich River.

As action by the water committee of the Legislature will be dependent upon an expression of opinion by the State Board of Health as to the feasibility of utilizing these brooks, we would respectfully request your Board to make such examination of the same as may appear necessary.

Subsequently a plan showing the proposed sources of supply was submitted, together with a report of your engineers describing the proposed works. Middleton Brook, mentioned in the application, is not shown upon the plan as a part of the scheme, and is not considered in the report of your engineers, and it is understood that this brook does not form a

part of the plan now under consideration. The plan provides for taking water first from Suntaug Lake in Peabody and conveying it by gravity either to Spring Pond, one of your present sources, or to the reservoir below Spring Pond, or directly into the pump well at the present pumping station, and for supplementing the supply from Suntaug Lake by pumping into it water from Fish and Boston brooks. In developing the latter streams it is proposed to construct upon each a reservoir holding about 100,000,000 gallons, but the location of these reservoirs is not shown upon the plans submitted.

A large quantity of water from the public works is used in Peabody for mechanical and manufacturing purposes, and the consumption of water in the town has increased very rapidly in the last few years, amounting in the year 1904 to 1,666,000 gallons per day, or about 135 gallons per inhabitant. It is understood that an additional quantity, amounting to from 200,000 to 300,000 gallons per day, is supplied by gravity from Spring Pond, one of your sources, to water takers in Salem, and that this amount is not included in the average daily consumption given above. An estimate of the capacity of your present sources of supply, compared with the quantity of water now used, shows that the consumption of water in Peabody is very greatly in excess of the capacity of the present sources in a dry period, and an additional supply is necessary.

The Board has carefully considered the application and report submitted therewith, and has caused the locality to be examined by its engineer and samples of the water of the various sources to be analyzed. Suntaug Lake, according to the information submitted, has an area of 156.5 acres and a drainage area of 336 acres, including the area of the pond. The yield of this source, if added to that of the present sources of supply, would not equal in a dry period the consumption of water in Peabody, so that if water should be introduced from this source it would be necessary to provide a further supplementary supply without delay. By pumping water into the lake from Fish and Boston brooks, with a reservoir on each holding 100,000,000 gallons, as proposed in the plan now submitted, a much larger quantity of water than is now required by Peabody could be obtained; but it would not be necessary for the town to use both of these sources, since either stream, if used in connection with Suntaug Lake and the present sources, or even with the present sources alone, would be ample for the requirements of Peabody for a long time in the future, so far as can now be foreseen.

The results of several analyses of the water of Suntaug Lake show that, while this water has but little color, it contains a larger quantity of organic matter than the waters of most of the natural ponds used as sources of water supply in the State. The analyses show that, at the

time these examinations were made, the water had frequently an unpleasant odor, and the Board is also informed that large growths of aquatic plants appear in the pond in the summer. So far as it is practicable to determine from the information available, it is probable that the water of this pond would be objectionable for drinking and other domestic purposes if supplied directly to consumers in Peabody. If the water should be turned directly into either Spring or Brown's ponds, your present sources of supply, it would undoubtedly have an unfavorable effect upon the quality of their waters. While in the past the water supplied to the town from these sources has usually been of good quality, it has occasionally been objectionable on account of the presence of microscopical organisms in large numbers and the disagreeable tastes and odors which they produce; and if the water of Suntaug Lake should be introduced, objections from these causes would very likely be more frequent and more serious.

The water-sheds of Fish and Boston brooks contain large areas of swamp land; and analyses of the water of these brooks made recently at a time of high flow, when the waters were probably better than at other seasons of the year, show that these waters are highly colored and contain a very large quantity of organic matter, due to the contact of the water with vegetable matter in the swamps through which it flows. The water of Boston Brook contains less color and organic matter than that of Fish Brook, so far as these examinations show; but if water from either of these sources should be diverted into Suntaug Lake it would have an unfavorable effect upon the quality of the water of the latter source, and make it still more objectionable, whether for use either as a direct supply or for supplementing your present sources.

While it might be practicable to purify the water supply of Peabody if it should be made seriously objectionable by the introduction of water from Suntaug Lake and Fish or Boston Brook, by filtration through sand, the additional cost would be considerable; and, in the opinion of the Board, it is very desirable for the town of Peabody, before building works to introduce water from Suntaug Lake or either of the other sources mentioned, to determine whether it is not practicable to obtain water of better quality in sufficient quantity for the supply of the town in some other way.

An additional water supply might be obtained from the metropolitan water system possibly at no greater expense than by the plan now proposed; and the water obtained in this way would be of much better quality than that which would be secured from the sources now proposed, unless works for filtration of the water should be installed.

If a supply of ground water could be obtained from some suitable

source sufficient for the requirements of Peabody, it would be more satisfactory than water from any surface source. It does not appear that investigations have been made with a view to securing an additional water supply for Peabody in this way; but there are indications that ground water could be obtained in considerable quantities in the valley of Fish Brook, and even more favorable conditions exist in the valley of Pye Brook, the water-shed of which is adjacent to that of Fish Brook, on the north. If ground water should be obtained in the latter valley, it is possible that some return upon the cost could be obtained by supplying water to the village of Topsfield, where no public water supply is in existence. There are also other localities in which it may be practicable to obtain a large quantity of ground water of good quality.

Under these circumstances, the Board does not deem it advisable for the town of Peabody to begin the construction of works at present for taking water from Suntaug Lake, with a view to supplementing this source from Fish or Boston Brook, but would advise a further investigation, to determine whether it is practicable to obtain water from some source which is likely to furnish water of satisfactory quality; and the Board would especially advise that investigations be made with a view to obtaining a supply of ground water sufficient for the further requirements of the town.

JUNE 1, 1905.

To the Committee on Water Supply of the Town of Peabody, MR. H. F. WALKER, *Chairman*.

GENTLEMEN: — The State Board of Health has considered your communication of May 4, 1905, relative to the proposed additional water supply for the town of Peabody to be taken from Suntaug Lake, and the report of your engineers submitted therewith, and has given the subject further careful consideration.

That the shortage of water in your present sources is serious there can be no doubt, and it is essential that provision be made without unnecessary delay to meet the present emergency, and to provide an adequate supply of water for the increasing requirements of the town. Taking up first the question of a permanent addition to the water supply of the town, the Board finds that Suntaug Lake has not sufficient capacity to meet the demands of Peabody. It further appears that the town is growing rapidly, and that the consumption of water during the coming summer is likely to be more than 2,000,000 gallons per day, — a quantity which is 30 per cent. or more in excess of the capacity of your present sources and Suntaug Lake together.

The taking of Suntaug Lake does not, therefore, solve the water-supply problem for Peabody, though it would relieve the present emergency; and, as your engineers state, it is reasonable to insist at the present time

on a consideration of what the final source is to be. From the information presented and the investigations made by the Board, there appear to be two practicable ways of obtaining a further supply of surface water for Peabody that is likely to be adequate for present needs and for the future requirements of the town, so far as they can now be foreseen. One of these plans is to take water from the Ipswich River or one or more of its tributaries, and the other to take water from the Metropolitan Water District. If water for the future supply of the town is to be taken from the Metropolitan Water District, this Board is unable to see, from the information presented, that the construction of works for taking water from Suntaug Lake would be of any permanent advantage to the town. If it be deemed desirable or advantageous to have a large quantity of water in store near the town, which might be used in an emergency in connection with the metropolitan supply, an ample storage is furnished by the present sources, which could always be kept available for this purpose.

If water is to be taken in the future from the Ipswich River or its tributaries, as proposed in your recent communication, the use of Suntaug Lake as a place of storage is unnecessary, since the waters from the Ipswich River could be delivered to your present sources probably at less expense than by delivering them into Suntaug Lake and drawing water thence to your present pumping station; and the Ipswich River or either one of the two tributaries — Fish or Boston Brook — suggested by you as additional sources of supply would be ample, if used in connection with your present sources alone, to furnish all of the water required by Peabody until the consumption of water becomes much greater than at present. As the Board has already advised, the quality of the water of the brooks referred to is so poor that if introduced directly into Suntaug Lake or your present sources of supply these waters would be rendered objectionable for drinking, and it would be necessary to purify them by filtration. This can apparently be done as well in connection with your present sources as if Suntaug Lake should be added to the system.

Regarding the other question at present requiring solution, — the best method of relieving the present emergency, — it is necessary that steps be taken at once to make provision for an additional water supply; since, if the present season continues to be a dry one, a shortage of water is likely to be experienced in the latter part of the year, and it is important that an additional water supply for temporary use be secured without delay. If an additional supply can be obtained from either of the neighboring cities or towns, this would probably be the best plan of meeting the present emergency; but if it is impracticable to secure a sufficient

additional supply in this way, then water must be sought from some other source. Of the sources available in the vicinity of the town, Suntaug Lake appears to be the most desirable. There are, however, summer camps and a summer hotel close to its shores, and a part at least of the village of South Lynnfield is probably within the water-shed. It is likely, however, that by the enforcement of suitable rules and regulations the water of the lake can be protected from serious danger of pollution by sewage.

The opinion of the Board, expressed in a previous communication, as to the quality of the water of Suntaug Lake, was based upon a considerable number of analyses, some of which were made many years ago and others during the past winter and spring; and these analyses, together with other information as to the condition of the water of this lake, indicate that it would be objectionable for drinking in the summer season on account of the presence of an excessive quantity of organic matter, chiefly microscopic organisms. The quality of the water of such sources usually varies in different years, and is less objectionable in some years than in others, and it is not known that organic matter of this kind is injurious to health.

Under the circumstances, the Board is of the opinion that if enough water cannot be obtained from neighboring municipalities, Suntaug Lake is the best available temporary source of supply for Peabody to meet the present emergency, until such time as an adequate water supply can be provided; and the Board would advise that, if works should be constructed for taking the water from this source, all takings be made so far as practicable under the laws relating to emergency sources of water supply, and that the works be of a temporary character.

The Board would again urge that investigations of possible sources of permanent water supply for Peabody be made without delay, and that these investigations be sufficiently thorough to show the comparative cost of works for obtaining water from each of the available sources, and the probable quality of water to be obtained.

As advised in the last reply of the Board, it is probably practicable for Peabody to obtain an adequate supply of excellent water, by means of wells or similar works, at some place in the valley of the Ipswich River or one of its tributaries. While objection is made that ground waters, on account of hardness and iron, are not suitable for use in the leather industry, this objection does not seem well founded, since about half of the ground waters of the State probably contain less iron than the water of Suntaug Lake, and a very large percentage of them also have less hardness. If a ground-water supply be introduced changes might be necessary in your present system in order to keep the water from exposure

to light, but this should not be a very serious difficulty; and it appears to the Board desirable that, in considering the question of a future water supply, the practicability of obtaining a supply of ground water should be thoroughly investigated.

The Board will assist you in further investigations, if you so request, by making the necessary analyses of water, and will give you further advice when you have the results of further investigations to present.

Penikese Island.

July 13, 1905.

To the State Board of Charity, State House, Boston, Mass.

Gentlemen: — The results of the analyses of samples of water sent by you to this Board for analysis and received at this office on July 11 are enclosed herewith. The water submitted is unfit for drinking or other domestic use.

Pepperell.

Aug. 3, 1905.

To the Water Supply Committee of the Town of Pepperell.

Gentlemen: — The State Board of Health received from you on May 8, 1905, an application for advice with reference to a proposed water supply for the town of Pepperell, containing the following statement: —

It is the wish of many of the citizens of the town of Pepperell to introduce a system of water supply in the town of Pepperell. Taking into consideration the decrease in population caused by the loss of the Leighton shoe factory by fire two years ago, we ask for your advice in regard to taking water from Sartelle meadow, so called, situated northwest of the centre of the town about one mile, and from Heald's Pond about one mile west of Pepperell Centre, or from any other source deemed by you most appropriate.

In response to this application, the Board has caused the sources indicated by you to be examined by its engineer and has considered the available information as to other possible sources of water supply available to Pepperell, as shown by records of previous investigations.

Of all the sources considered, the plan of taking water from the ground in or near the Sartelle meadow in the valley of Sucker Brook has received the most thorough consideration, and test wells have been driven at many points along the valley of this stream, and samples of water from some of the wells have been analyzed. The results of the analyses have shown that the water of the test wells is in most respects of good quality for the purposes of a public water supply; but the hardness of this water is greater than that of any of the sources of supply now used by cities and towns in the State, with two or three exceptions.

The tests also show that in the lower part of the valley near the mouth

of the brook ledge is encountered very close to the surface, and that the conditions are unfavorable for obtaining water from the ground in considerable quantity throughout much of the valley below the Sartelle meadow. The same appears to be true of the portion of the valley above the mill ponds above Sartelle meadow, so that the area from which ground water can be obtained freely is limited practically to the meadow and its immediate neighborhood, including the territory about the two small mill ponds above it. The tests show further that the depth of porous soil is not great, and that the conditions, on the whole, are unfavorable for obtaining a considerable quantity of water in this valley. Moreover, the water is liable to pollution from the dwelling house and other buildings situated at the head of the Sartelle meadow, and these would doubtless have to be purchased and removed in case water should be taken from the ground in this region.

While the quantity of water obtainable from the valley of Sucker Brook in the Sartelle meadow and its neighborhood is limited, it is possible that it would be sufficient, if used economically, to meet the requirements of the present villages of Pepperell and East Pepperell, in which the population is not at present increasing, but even this is doubtful; and if it should be decided to attempt to supply the town from this source, a supplementary supply would probably soon be found necessary. The source suggested as a supplementary supply is Heald's Pond, located about one mile west of Sucker Pond; and this source could probably be obtained with as little expense as any from which it would be practicable to supplement the water supply, if works should be located in the Sartelle meadow.

Heald's Pond has an area, as shown upon the State map, of about 10 acres, and its drainage area is about one-third of a square mile. It would be practicable to increase the storage capacity at little expense by the construction of a dam at the outlet of the pond; and it is probable that enough water could be obtained from this source, in conjunction with wells in the Sartelle meadow, to supply the villages of Pepperell and East Pepperell, and allow for a considerable growth in population, if the use of water should not be excessive.

The water-shed of Heald's Pond is practically uninhabited, and the water is not at present exposed to serious danger of sewage pollution; but analyses of the water show that it is affected by the presence of a large quantity of organic matter, and it would doubtless be objectionable at times for drinking and other domestic purposes, on account of a disagreeable taste and odor.

At the time of the previous investigations for a water supply for Pepperell, wells were driven at many places along Unquetenassett Brook, and

the valley of this stream was quite thoroughly examined to determine the practicability of obtaining a water supply for Pepperell therefrom. The results of the tests showed that in the upper portion of this valley, about a mile above Cummings' Mill, so called, and two and one-half miles from the middle of the village of East Pepperell, the conditions were very favorable for obtaining water in large quantities from the ground by means of wells or other works; and analyses of the water showed that it was probable that the ground water in this locality is soft, and in other respects of excellent quality for the purposes of a public water supply.

The initial cost of works for taking water from this valley and supplying it to the villages of Pepperell and East Pepperell would probably be somewhat greater than the cost of works for taking water from the valley of Sartelle meadow; though, if the cost of protecting the latter source from pollution by the removal of buildings by which the water is liable to be affected should be included, the difference in the cost of works from the two sources would probably not be considerable. If it should be necessary to supplement the supply obtainable from the Sartelle meadow and its neighborhood with water from Heald's Pond or some other source, the cost of the works would probably be much greater than the cost of obtaining a sufficient supply from the valley of Unquetenassett Brook.

Of all the possible sources of water supply available to Pepperell, it appears to the Board that the investigations have shown that the valley of Unquetenassett Brook is the most favorable, both in the quantity of water available and its probable quality; but it is advisable, in the opinion of the Board, before definitely locating works for supplying Pepperell in this valley, that a further test be made by sinking additional wells in the more favorable places, and subsequently pumping from a group of wells, in the locality found to be most favorable, for a period of a week or more, and at such a rate as would be necessary for the supply of Pepperell. If you decide to make such a test, the Board will assist by making the necessary analyses of water, and will give you further advice when the results of the test are available.

Royalston (Wells in South Royalston).

Nov. 2, 1905.

To Mr. Charles H. Brooks, *Chairman, Board of Health, Royalston, Mass.*

Dear Sir: — In accordance with your request of Oct. 5, 1905, the State Board of Health has caused three wells in South Royalston, known respectively as the Depot well, the East well and the West well, to be examined and samples of their waters to be analyzed.

The water of the so-called East well is very badly polluted, and its further use should be prevented. The water of the Depot well contains a larger quantity of organic matter and bacteria than is found in good well waters, and the well cannot be regarded as a safe source of drinking water. The water of the West well when examined was probably safe for drinking.

Russell.

June 1, 1905.

To the Water Supply Committee of the Town of Russell.

Gentlemen: — The State Board of Health received from you on April 28, 1905, an application requesting the approval by the Board of the use of Black Brook as a source of water supply for the town of Russell, the water to be taken at a point about one mile from the point where the brook enters the Westfield River; and the Board has caused the brook and its water-shed to be examined by one of its engineers and samples of its water to be analyzed.

The results of these analyses show that the water is naturally of good quality for the purposes of a public water supply, and the area of the water-shed is such that a sufficient supply for the present requirements of Russell can without doubt be obtained from this stream. The water-shed contains several dwelling houses and farm buildings, most of which are so located that the pollution of the brook therefrom can be prevented by the enforcement of suitable rules and regulations, which this Board will provide if you so request. One of these groups of farm buildings is so situated with reference to the stream that it will be impracticable to prevent the danger of the serious pollution of the stream from this place, and the Board would advise that these buildings be purchased and removed before the water is used for the supply of the town.

It also appears that there is a sawmill located close to the brook, from which sawdust and possibly other polluting matters are discharged into the stream. This source of pollution should also be removed before the water is used. By making these changes and by means of the enforcement of suitable sanitary rules this water may safely be used for domestic purposes.

The Board hereby approves the use of this stream as a source of water supply for the town of Russell, with the understanding that the sources of pollution indicated are to be removed and sanitary regulations established before the water is used.

Salem.

April 6, 1905.

To the Salem Water Board, Mr. Charles A. Archer, *President*.

Gentlemen: — The State Board of Health has considered your request for advice as to whether the water of Longham basin is suitable to use for the water supply of Salem and Beverly by diverting it into Wenham Lake, and whether this water is likely to affect noticeably the taste or odor of the lake water, and has examined the results of the recent analyses of the Wenham Lake water and of Longham Brook water and the results of other examinations of the waters of these sources made in previous years.

It is evident, from an examination of the results of numerous chemical analyses of the water of Wenham Lake, covering a period of many years, that the introduction of water from Longham Brook since 1895 has had an unfavorable effect upon the quality of the lake water, which has been of poorer quality since the year mentioned than it was before that time.

The Board has already advised you, in response to previous applications, to use the water of Longham Brook only at times in the winter and spring when its quality was least objectionable, and has assisted in previous years by making analyses of the water to determine its quality in the winter and spring seasons. The analyses made during the past three months show that the water of the Longham source has been of poorer quality than is usually obtained from this source during the period of high flow in the spring; and the diversion of water containing so large a quantity of organic matter into the lake would be likely to have an unfavorable effect upon the quality of the water of the latter source. It appears, however, that the water of Wenham Lake has been drawn to a very low level during the present winter; and it also appears, from a comparison of the consumption of water in Salem and Beverly during the year 1904 with a careful estimate of the capacity of Wenham Lake and Longham Brook taken together, that the quantity of water now used by the two cities is about equal to the capacity of your sources of supply in a series of dry years.

Under these circumstances, it will probably be necessary hereafter to divert all of the water of Longham Brook into Wenham Lake; and if the use of water in Salem and Beverly continues to increase as in the past few years, it will be necessary for the two cities to secure a further additional source in the immediate future. The water of the Longham source, even when used only in the period of the year when the quantity of organic matter present is lowest, has had an unfavorable effect upon the water of Wenham Lake; and the use of all of the water of the Long-

ham Brook source, which is now necessary in order to secure an adequate supply for the two cities, will doubtless have a further unfavorable effect upon the water of Wenham Lake.

Under the circumstances, it is very important, in the opinion of the Board, that you determine whether it is practicable to improve materially the quality of the Longham Brook water by cleaning the reservoir and draining the swamps on the water-shed.

The Board has already advised you, in response to a previous application, that measures be taken to improve the Longham Brook source, the most recent advice with reference to this matter having been given in 1901, as follows: —

It will be necessary, as the population of the cities grows and the use of water increases, to take a larger and larger quantity of water from this stream, and ultimately take the whole flow of the stream and utilize all the storage available in the reservoir; and when this becomes necessary, the water, unless greatly improved over its present state, will have a very unfavorable effect upon the quality of the water of Wenham Lake. Longham Reservoir is a very unsatisfactory basin for the storage of water, but it can be greatly improved by removing the mud and organic matter from its bottom. Very little gain will be made by improving the reservoir, however, unless the quality of the brook water stored in the reservoir can be greatly improved. The water of Longham Brook is naturally of a very poor quality, owing to long contact with vegetable matter in the meadows and swamps through which it flows; and, as stated in previous replies of the Board, it is important that its quality be improved as far as practicable by draining the meadows and swamps, so that it may not seriously injure the quality of the water of Wenham Lake. It appears that some work in draining the meadows has already been done, but further improvement could apparently be made by more thorough drainage; and the Board would advise that all the improvement possible be made in this stream now, when the work can be done at times when it is not necessary to use the water.

If you will submit surveys of these meadows and swamps and plans for their drainage, the Board will, upon application and receipt of the plans, advise you concerning them.

It does not appear that any considerable amount of work has been done toward improving the water of the Longham source, and the quality of the water remains about the same as in previous years. The Board would again advise that the question of the practicability of improving the quality of this water be taken up and considered without delay; and since the consumption of water in the cities is already practically equal to the capacity of your sources in a period of dry years, it is also important, in the opinion of the Board, that you consider the practicability of supplementing the supply from some other source.

The Board will assist you in further investigations as to improving the Longham Brook water or securing a water of good quality from some

other source of supply by making the necessary analyses, and will give you further advice in the matter when the results of further investigations are available.

Scituate (E. C. Carlton).

Oct. 5, 1905.

To Mr. E. C. Carlton, *East Milton, Mass.*

Dear Sir: — In response to your request of Aug. 14, 1905, for an examination of the water of a well on the premises of the Misses Cudworth, Main Street, Scituate Centre, used as a source of water supply by three or four families, the Board has caused the well and its surroundings to be examined and samples of the water to be analyzed.

The results of the analyses show that the water contains a considerable quantity of organic matter and a larger number of bacteria than is found in good well waters.

The well is exposed to pollution from the sink drain, and is liable to be affected by seepage from the privy vault, into which the sink drain discharges. The method of drawing the water is also objectionable. By changing the location of the sink drain and privy, so that if any break or leakage should occur these wastes would have to filter a long distance through the ground before entering the well, and by changing the method of drawing the water, providing a suitable pump for that purpose, the water of this well might still be used with safety for drinking. It would be better, however, to secure a drinking water at a greater distance from possible sources of pollution.

Southbridge.

June 29, 1905.

To the Southbridge Water Company, Southbridge, Mass.

Gentlemen: — The State Board of Health has considered your application for advice as to the construction of a second reservoir on Hatchet Brook, above the present reservoir on that stream known as Reservoir No. 3, and the plan of filtering the water of the new reservoir, and has caused the locality to be examined by its engineer.

The plan provides for the construction of a dam about 400 feet above Reservoir No. 3, which will create a reservoir having an area of 66 acres and a capacity of about 185,000,000 gallons. The maximum depth of the reservoir will apparently be about 19 feet and the average depth a little less than 9 feet. Plans of the filters have not as yet been presented, but it is understood that they are to be located between the new reservoir and the present Reservoir No. 3, that they are to be constructed of sand and gravel to a depth of about 5 feet, and that the water is to be applied intermittently and subsequently collected and delivered into the pipe leading to the town.

The water-shed of Hatchet Brook contains very few dwelling houses, and the danger of pollution of the stream from these places is at present very slight and can be prevented without difficulty. The quality of the water of the present reservoir on Hatchet Brook is shown by the results of analyses of numerous samples collected within the past nine years. In the earlier years after the completion of the reservoir the water was highly colored, and contained usually a very large quantity of organic matter. Its quality has improved, but the water is usually affected in the latter part of the summer or early fall by the presence of a large quantity of organic matter, and has at times much color and a disagreeable taste and odor. The water of Hatchet Brook as it enters the reservoir is somewhat colored, but contains much less organic matter than the water of the reservoir; and the poor quality of the reservoir water is probably due largely to contact with organic matter in its bottom. The water of Hatchet Pond is nearly colorless, and contains very little organic matter for a pond water.

About half the area to be flowed by the proposed new reservoir consists of a meadow and swamp containing peaty soil, and there is a considerable depth of loam and vegetable matter on the remaining portion of the area. If the proposed new reservoir should be filled without further preparation than the clearing of the site of trees and other vegetable matters, there is no doubt that the water would take up organic matter in large quantities from the soil and peat with which it would come in contact, and would be affected by excessive growths of organisms, which would make it very objectionable for water supply purposes. Experiments upon the purification of such waters show that during the part of the year, usually in the summer, when the quantity of organic matter present is greatest, they cannot be purified by ordinary methods of filtration, such as that proposed in this case, but by double filtration and aeration such waters can probably be made satisfactory for drinking. The cost of the necessary works and their maintenance would be large, and the results would depend very largely upon the skill and care with which they were operated.

It has been the practice for many years, in the construction of storage reservoirs for water-supply purposes, to prepare them for the purpose by removing all of the soil and organic matter from the area to be flowed, or, in cases where the depth of objectionable soil was too great for removal, by covering it so as to prevent the water from coming in contact with it. Experience has shown that the water of reservoirs prepared in this way contains much less organic matter and is in other respects of much better quality than the water of reservoirs from which the soil and organic matter have not been removed.

If the proposed new reservoir should be given a thorough preparation for the storage of water in the manner indicated, it is probable that the water would be nearly colorless and usually satisfactory for domestic purposes. The reservoir is quite shallow, however, and there might still be times when the water would be affected by growths of organisms and the disagreeable tastes and odors which they produce, but troubles of this sort would probably not be of frequent or regular occurrence.

The Board would therefore advise that, in the construction of the proposed reservoir for an additional water supply, the bottom of the reservoir be prepared in a thorough manner for the storage of water by the removal of all the soil, stumps and organic matter from the area to be flowed. If places are found where the peaty deposits extend to such a depth that their removal is impracticable, the soil may be allowed to remain, provided it be efficiently covered to a depth of one foot or more with sand and gravel.

Since it is possible that the water of the reservoir may still be affected at times by objectionable taste and odor, and since it might be possible to avoid the use of much of the water at such times by taking water from Hatchet Brook above the reservoir, or Hatchet Pond, the Board would advise that a small basin be built on Hatchet Brook just above its entrance to the reservoir, and that a pipe line be extended through the reservoir to this basin, so that the water of the brook or Hatchet Pond may be drawn directly into the lower reservoir or into the town in case it should be found desirable. Such a pipe line would be of much assistance in providing good water for the supply of the town during the construction of the reservoir. The Board would further advise that the lower reservoir be drawn off, and its bottom thoroughly cleaned and prepared in the manner advised in the case of the upper reservoir.

When these works have been completed it should be practicable to supply the town at nearly all times with water which will not have an objectionable color, taste or odor; but if, for any reason, further treatment should be found desirable, the water could doubtless be rendered satisfactory by single filtration through beds of sand and gravel in the manner suggested.

It will be necessary during the progress of this work to introduce considerable numbers of men into the water-shed of Hatchet Brook above the point from which water is drawn for the use of the town, and it is of the greatest importance that the pollution of the water should be prevented. The Board would advise that suitable provision for maintaining proper sanitary conditions within the water-shed and preventing the pollution of the water be made in the beginning and strictly enforced.

The Board would also advise that, if the use of Reservoir No. 1 is to be continued, provision be made for preventing its pollution by the population within its water-shed.

Spencer.

Sept. 7, 1905.

To the Board of Water Commissioners of the Town of Spencer.

Gentlemen: — The State Board of Health received from you on August 12 the following request for approval of the use of the water of Whittemore or Moose Pond in Spencer as a temporary source of water supply, under the provisions of chapter 25, section 35, of the Revised Laws, and chapter 361 of the Acts of the year 1902, to relieve the emergency now existing by reason of the shortage of the water supply from Shaw Pond: —

> Acting under authority of chapter 361 of the Acts of 1902, we hereby petition your Honorable Board that you will approve the water from the pond known as Whittemore or Moose Pond, situated in said town of Spencer, as a proper source of water supply, to relieve the emergency now existing in said Spencer, from the inability of Shaw Pond, our permanent source of supply, to furnish the amount of water necessary for our consumption.

You further state that you propose to erect a pumping station near the upper end of the pond, to pump the water into the present main leading from Shaw Pond.

In response to your request, the Board has caused the pond and its surroundings to be examined by its engineer and a sample of water to be analyzed.

The pond is situated very close to the village of Spencer, and drains an area of less than a square mile, as measured from the State map. The water-shed contains a considerable number of dwelling houses, and the population within the water-shed is apparently about 130. Most of the buildings are located at considerable distances from the pond or its feeders, and it will probably not be very difficult or expensive to prevent polluting matters from the buildings from reaching the pond. There are, however, two outbuildings on the shore of the pond within the area of the town park, from which at the present time polluting matter could find its way readily into the pond; and there are also a barn near the westerly end of the pond, and one or two other buildings from which pollution might enter the pond or its feeders directly.

The quality of the water of Whittemore Pond is not very different from that of Shaw Pond at the present time, but the water of Shaw Pond is usually of much better quality than shown by the recent analysis. The water of Whittemore Pond has somewhat more color than

that of Shaw Pond, judging from the recent examination, and shows to some extent the effect of the population within its water-shed. It is not possible to determine definitely from a single analysis the general quality of the water of Moose Pond, but, so far as can be judged from the information available, the water is not likely to be as satisfactory as that of Shaw Pond.

The Board hereby approves the use of Whittemore Pond, or Moose Pond, as a temporary source of water supply for the town of Spencer, under the provisions of the laws herein mentioned; but the pond should not be used as a source of water supply until the privies on the park land and their contents have been removed, and adequate provision made to prevent pollution from other buildings from entering the pond.

Spencer (Isaac Prouty & Co.).

Dec. 7, 1905.

To Messrs. Isaac Prouty & Co., *Spencer, Mass.*

Gentlemen: — In response to your request of March 28, 1905, for an examination of the water of a deep tubular well from which it is desired to supply drinking water to the 1,500 employees in your factory, the State Board of Health has caused the well and its surroundings to be examined by one of its engineers and several samples of the well water to be analyzed.

From the information furnished to the Board, it appears that the tubular well from which it is proposed to take the water is 8 inches in diameter and has been drilled principally in rock to a depth of about 500 feet.

The results of the analyses show that the water entering the well has at some time been polluted and not thoroughly purified in its passage through the ground, and, in its present condition, the water cannot be considered safe for drinking. It is understood that the water is used for washing and other purposes in the factory; and the Board will continue to make analyses from time to time, if you will collect the samples, and will advise you if any material improvement takes place in the quality of the water.

Springfield.

Feb. 2, 1905.

To the Board of Water Commissioners of the City of Springfield.

Gentlemen: — The State Board of Health received from you on July 12, 1904, under the provisions of section 117 of chapter 75 of the Revised Laws, the following application for advice relative to a proposed system of water supply for the city of Springfield: —

The city of Springfield desires the advice of your Board on the matters, conclusions and recommendations contained in the accompanying report of the special

commission on water supply of Springfield, presented to the city council on June 6, 1904, and by the council referred to the board of water commissioners. As explanatory of this report, and furnishing the information upon which it is largely based, there is also submitted to you the earlier report of the same special commission, submitted to the city council of Springfield on March 28, 1904, together with the reports of the expert engineers employed by the special commission to thoroughly investigate the entire question of a municipal water supply for Springfield.

As it is imperative that the city should be provided with a palatable and satisfactory water supply at the earliest practicable date, and as the report of the special commission contains specific findings and recommendations, as set forth clearly and unequivocally therein, and as the whole matter of the improvement of the water supply has been under investigation and consideration during the last three years, the undersigned believe that, with the information obtained by all the surveys, investigations, filtration tests, chemical and microscopical examinations, final conclusions may now be reached by your Board, and advice be so explicitly given as to settle, to the satisfaction of all, the entire question of the future water supply of the city, and the appropriate and most economical programme of expenditure to be immediately taken up and followed in accordance therewith. To this end the advice of your Board is now respectfully requested.

This application was accompanied by a copy of the printed report of the special commission on water supply of the city of Springfield to the city council, dated June 6, 1904, containing the conclusions and recommendations of the commission, concerning which the advice of the Board is now desired; and was also accompanied by the earlier report of the special commission on water supply mentioned in the application, which was presented to the city council of Springfield March 28, 1904.

It appears that, as a result of its earlier investigations, presented in its first report, the commission recommended to the city council that every endeavor be made to secure the passage of the bill as presented to the Legislature last year, with the petition of the mayor and board of water commissioners, which petition prayed for authority for the city to use as its future source of water supply the east and middle branches of the Westfield River in Huntington. That petition having been denied by the Legislature, the special commission, as a result of further investigations, then presented to the city council another plan for securing an adequate supply of good water for the city of Springfield, which is described in the report of June 6, 1904. The plan provides for developing the present sources of supply, and supplementing them when necessary from Twelve Mile Brook and the Scantic River, and it is this plan concerning which the advice of the Board is now desired.

Upon receipt of the application on July 12, 1904, the engineer of the Board requested that the plans and other information upon which the conclusions and recommendations in the report of June 6, 1904, were

based, be submitted for the information of the Board; and subsequently, on Oct. 27, 1904, plans of the proposed system of water supply were received from the engineer of the special commission, — Mr. W. H. Brainerd; and on Nov. 14, 1904, a third report of the special commission on water supply, presented to the city council of the city of Springfield on Oct. 31, 1904, was received by the Board, containing modifications of the system proposed in the report of June 6, 1904, due to the further study and investigation made by the commission and its engineer between July 12 and the date of presenting the last report.

The essential features of the plan of the special commission for a system of water supply for the city of Springfield, as described in its report of June 6, 1904, and as subsequently modified and further described in the report of Oct. 31, 1904, and the plans accompanying that report, provide for building a new storage reservoir on Axe Factory Brook; for conducting the waters of the Jabish and Broad brooks into this reservoir by means of a new canal, utilizing, however, a part of the present Jabish Brook canal; for a pipe line to convey the water of this new reservoir to the present Ludlow basin, or possibly to filters to be constructed below the Ludlow dam; and for a filter plant designed to purify the water of the Axe Factory and Ludlow reservoirs by single filtration at a rate of 5,000,000 gallons per acre per day. In connection with this plan it is proposed to improve the water-shed of Jabish Brook by cleaning the bottom of the Knight and Gold reservoir, draining the swamps, purchasing and removing the mills and draining the mill ponds; to improve the portion of the old canal to be used, to clean up the shores of the Ludlow Reservoir and to improve the dam and canal at Higher Brook.

In the operation of the works it is proposed to use the waters of the Axe Factory Reservoir for the supply of the city after single filtration during the periods when the water of Ludlow Reservoir is affected by *Anabæna* to such an extent that it cannot be purified by single filtration, but to use the water of Ludlow Reservoir after single filtration at the rate proposed at other times.

In order to increase further the capacity of the Ludlow sources when necessary, it is proposed to construct a reservoir at the lower end of the Jabish Brook water-shed, holding about 1,500,000,000 gallons of water, which will, presumably, be drawn into the Axe Factory Reservoir as required, and thence be allowed to flow either into the Ludlow Reservoir or through the pipe line to the Ludlow basin or the filters. As a further source of supply when necessary, when the capacity of the Ludlow sources thus developed has been reached, it is proposed to use the waters of Twelve Mile Brook, a tributary of the Chicopee River in the towns

of Wilbraham and Monson; and as a still further increase when necessary in the future, it is proposed to use five tributaries of the Scantic River in the town of Hampden.

The Board has caused the various sources and the sites of the proposed reservoirs to be examined by its engineer, has examined carefully the plans and reports submitted, and has considered the available information as to the storage and purification of water, especially the results of the numerous examinations of Ludlow waters and experiments upon the purification of these waters and similar waters elsewhere.

The object of the investigations relative to an improved water supply for the city of Springfield, which have been made from time to time since the works were first constructed in 1875, and especially during the last fifteen years or more, has been to secure a water supply free from offensive taste and odor. In the course of this effort to secure a better water supply many plans have been investigated previous to the one now under consideration. In the mean time the city has been growing rapidly, and the use of water has been increasing until at the present time it equals the capacity of the Ludlow works, — in fact, probably exceeds their capacity in a dry season. The problem before the city, then, is not only to improve the quality of the water supply, but to secure a larger quantity of water.

The plan now presented is intended to accomplish both objects. It is proposed to secure a larger quantity of water from the present sources of supply by building a new reservoir on Axe Factory Brook, to hold 825,000,000 gallons, and by conducting into it the waters of Jabish and Broad brooks; and it is expected to secure a water of satisfactory quality by building filters below the Ludlow dam for the single filtration of the water of the Ludlow and Axe Factory reservoirs at a rate of 5,000,000 gallons per acre per day, using the water of the Axe Factory Reservoir and the tributary canals, including presumably Higher Brook, for the whole supply of the city when the water of Ludlow Reservoir cannot be purified by single filtration. By the adoption of this plan the city of Springfield is advised that a water supply can be secured which will be superior to that of any city in New England, and which will be sufficient for the supply of the city for the next ten or twelve years.

The results of experience in the use of water from storage reservoirs which have been prepared by the removal of all the soil and organic matter from the area to be flowed, or by covering the organic matter with sand or gravel where too deep to excavate, have shown that the reservoirs of smaller capacity and depth, similar in these respects to the proposed Axe Factory Reservoir, have been affected at times by organisms such as *Anabœna, Synura.* and *Uroglena,* which have rendered the

water objectionable on account of a disagreeable taste and odor. The larger and deeper reservoirs do not appear thus far to be seriously affected by organisms, or at least have not been affected in an equal degree.

If the Axe Factory Reservoir should be used as proposed, to furnish the whole supply of the city in the time of greatest consumption, it will be drawn down rapidly, and its waters are likely to be affected in the same manner as those of the small storage reservoirs.

The plan submitted assumes that the water of the proposed Axe Factory Reservoir can be purified during the summer and autumn seasons by single filtration at a rate of 5,000,000 gallons per acre per day; but there is no record of experience in the filtration of such waters sufficiently thorough and extended to show whether or not such a water as that which this reservoir is likely to contain could be purified efficiently by single filtration at the rate proposed. The experience in filtering the canal water mingled with a small quantity of water from the Belchertown Reservoir, containing *Anabœna,* in 1901 showed that such a water could not be purified by single filtration when containing small numbers of *Anabœna;* and the waters of reservoirs like that proposed on Axe Factory Brook are often affected not only by *Anabœna* but also by other organisms which cause offensive tastes and odors, concerning the removal of which by filtration very little is known.

The plan also assumes that the water of the present Ludlow Reservoir could be efficiently purified by single filtration at a rate of 5,000,000 gallons per day at times when it is not affected by *Anabœna.* While it is true that the tastes and odors were largely removed from the Ludlow water by single filtration except in the period of the prevalence of *Anabœna* during the experiments of 1901, the water in that year was of better quality than usual; and it is unsafe to assume that the Ludlow water could be efficiently purified by single filtration at all times when not affected by *Anabœna.* Moreover, the quality of this water may change considerably in the future from natural causes, and it may be unfavorably affected by the discharge into it of water from the Axe Factory Reservoir under the plan now proposed.

The evidence on the whole shows that there is much doubt as to whether the water of the Axe Factory Reservoir and of the Ludlow Reservoir, even when free from *Anabœna,* can be purified efficiently by single filtration at the rate proposed, so as to supply the city with water free from taste and odor.

It is evident also, from a study of the capacity of the Axe Factory Reservoir and the probable yield of the various water-sheds compared with the quantity of water used by the city and the average length of the

"*Anabæna* epidemic," so called, in Ludlow Reservoir, that the proposed Axe Factory Reservoir would not, even at the present rate of consumption of water, furnish enough water in some years to supply the city during the period when the water of Ludlow Reservoir is affected by *Anabæna;* and that it would frequently be necessary to use Ludlow water at the times when *Anabæna* are usually present in large numbers. If the plan should be carried out, therefore, it is probable that the city would still be supplied at times with water having an offensive taste and odor.

The assertion that the Ludlow water itself could be improved so as to be susceptible of purification by single filtration, by raising the water level, discharging more water through the reservoir, — thereby increasing the circulation, — cleaning the shores of the reservoir and removing the jelly mass which appears in this water at times, not only has no evidence to support it, but there is much evidence that such is unlikely to be the case.

The increase in the capacity of the present sources that would be obtained by the construction of the Axe Factory Reservoir would amount to only about 10 per cent. over the quantity of water now used and the present capacity of the works, — an insignificant quantity, when compared to the rapid growth of the city of Springfield, even assuming that a reduction in the consumption of water can be made by the checking of waste.

The assertion is made that over 50 per cent. of the water now used in Springfield is wasted, and that it is possible to control this waste. A consideration of the draught of water in Springfield indicates that the actual use of water for domestic purposes by the people of the city is greater than in many cities, and that the higher rate of consumption in Springfield is due, in part at least, to this use, and not alone to waste. It also appears that much water is used for mechanical and manufacturing purposes, and that the cutting off of this use of water at the present time would be disadvantageous to the city. Under these circumstances it is unsafe to assume that a large reduction will be made in the use of water in the city of Springfield, at least until the facts as to the use and waste of water have been more definitely ascertained.

Finally, the estimates of the cost of the works for developing a supply of good water free from taste and odor from the Ludlow sources by the construction of the Axe Factory Reservoir, filters and other works, as proposed by the special commission, — the amount of which is about $700,000, — appear to be entirely inadequate for the work required. It seems evident, from the information furnished by the engineers of the city of Springfield, that, in order to convey to the city from the present sources of supply a sufficient quantity of water for the requirements of

the city at all times, a new main pipe is necessary. The cost of this item has not been included in the estimate presented, other items are omitted, and the cost of others has evidently been underestimated. Assuming that the cost of the proposed Axe Factory Reservoir would be as low as the cost of such reservoirs in other cities and towns, the total cost of the works proposed by the special commission, including a pipe line to convey the water to the city, would be as much as twice the amount estimated in the reports of that commission to be sufficient for this work. For the expenditure of this amount of money the city would obtain a water supply having a capacity only about 10 per cent. in excess of the capacity of the present works and the quantity now used, so that a further supply would probably be required within a very short time, while the quality of the water supplied might frequently be very objectionable.

In order for the city of Springfield to insure a satisfactory water supply from the Ludlow sources, double filtration will be necessary; and in order to secure enough water, a larger storage capacity must be provided.

The plan of the special commission for increasing further the capacity of the Ludlow sources, after their capacity, with the proposed Axe Factory Reservoir, has been reached, is to construct a new reservoir near the lower end of the Jabish Brook water-shed, to be used in conjunction with the Axe Factory and Ludlow reservoirs.

It is proposed to clean this Jabish Brook Reservoir thoroughly; but the estimate presented of the cost of this work — $190,000 — is inadequate for the purpose, judging from the cost of similar reservoirs elsewhere. In order to build this reservoir in a thorough manner, as proposed, judging from the cost of other reservoirs in many cities and towns, the cost would probably be as much as three times the estimate given; and adding this to the cost of the other works, including also in the estimate an allowance for the double filtration of the water, based on the lowest estimate thus far made for a filter of sufficient capacity to properly purify the water, the total cost of works for obtaining an adequate supply of good water from the Ludlow sources sufficient for the next ten or twelve years under the plan now proposed would be about two and a quarter millions of dollars. These works would supply about 14,500,000 gallons per day, or about 38 per cent. more water than is now used, — assuming that the quantity amounts on an average to 10,500,000 gallons per day, as given in the report of March 28, 1904.

The special commission on water supply strongly recommends, in its report of June 6, 1904, the immediate construction of the Axe Factory Reservoir and the proposed tributary canals, together with the proposed filters for the single filtration of this water, — works which, as already

shown, would only increase the yield of the Ludlow sources about 10 per cent. over the present yield and the present consumption of water, and could not be depended upon to supply the city with a water free from taste and odor. Consideration of the further investigations of this commission, as presented in its report of Oct. 31, 1904, indicates that a larger quantity of water could be obtained from the Ludlow sources by constructing the proposed Jabish Reservoir than by constructing the Axe Factory Reservoir; and that there would, furthermore, be a better chance of avoiding the necessity for supplying Ludlow water to the city when affected by *Anabæna* by constructing the Jabish Reservoir than there would by constructing the smaller Axe Factory Reservoir.

By the construction of the Jabish Brook Reservoir the capacity of the Ludlow sources would be increased a little over 30 per cent.; and the development of the Ludlow sources would doubtless be carried as far as it would be economical to attempt to develop them, since the subsequent construction of the Axe Factory Reservoir would increase the yield of the sources by less than a million gallons per day, — a quantity disproportionate to the probable cost of that reservoir and the attendant works. The best practicable plan of developing the Ludlow sources, therefore, judging from the information presented to the Board, would be to avoid the construction of the Axe Factory Reservoir and to build the Jabish Brook Reservoir in the beginning; and by this plan the cost of the works for enlarging the yield of the present sources about 30 per cent., and supplying water which had been treated by double filtration, might not exceed one and three-quarters millions of dollars.

Returning to the plan under consideration, it is proposed, after the capacity of the Ludlow sources, including the Axe Factory and Jabish Brook reservoirs, has been reached, to supplement the supply by taking the waters of Twelve Mile Brook and subsequently certain tributaries of the Scantic River. The water-shed of Twelve Mile Brook is stated in the report submitted to be of about the same area as that of Jabish Brook (10.6 square miles), but measured from the State map the area of this water-shed above the proposed intake reservoir is about 6.44 square miles; and the use of this source, developed as proposed in the plan submitted, would increase the yield of the sources to about 18,400,000 gallons per day.

The water of Twelve Mile Brook, under the plan submitted, is to be conveyed to the neighborhood of Ludlow Reservoir by a pipe line about 7 miles in length, and there filtered before being supplied to the city. The reservoirs are apparently to be prepared in a very thorough manner for the storage of water; but the reservoirs are not large, and, so far as can be judged from the limited information available as to the quality of the

water, the water of these reservoirs is likely to be affected at times by growths of organisms and disagreeable tastes and odors. Some of the items for taking water from this source are also much smaller than similar works have cost elsewhere. Increasing these items would bring the cost of works for taking water from this source to as much as $800,000.

After the capacity of the works with the Twelve Mile Brook reservoirs has been reached, the plan provides for taking water from the tributaries of the Scantic River directly to Springfield through an independent pipe line about 12 miles long, by works which will cost, as estimated by Fuller & Gray, about a million and a half of dollars. If developed in the manner proposed, the addition of these sources would increase the yield of the various sources of water supply available to Springfield to about 28,000,000 gallons per day.

It is difficult to predict the probable quality of the water that would be obtained from the proposed reservoirs on the tributaries of the Scantic River, from the very limited knowledge of the quality of the waters of these streams; but the reservoirs are comparatively small ones, and, so far as the available information shows, the water is likely to be affected at times by growths of organisms and by disagreeable tastes and odors. It is probable that, in order to secure a water free from taste and odor from these sources, filters would be required, which would increase further the cost.

It is not possible to predict for how long a time the Ludlow, Twelve Mile and Scantic works, as proposed in the plan now before the Board, would supply enough water for the city of Springfield, though it may be assumed that these works would last for the next thirty years, — a comparatively short period in the life of a city.

The total cost of the works developed in this way would probably be in the end more than $4,000,000, aside from the expense of maintaining the filters. A considerable saving would be effected in the cost of the development of the proposed sources by omitting the Axe Factory Reservoir, without materially reducing the capacity of the works; but the Board believes that the development of the Ludlow sources, with the use of the Twelve Mile and Scantic sources as auxiliary supplies in the future, up to the time when the capacity of these sources would be reached, would be more expensive for the city, and the difficulty of obtaining good water from them far greater, than from other and better sources, of which there are several apparently available in the neighborhood of the city.

The Board has examined the available information as to other possible sources of water supply in the region about the city of Springfield, and has compared the relative advantages of the various sources so far as is practicable with the information at hand. Of those sources which are

apparently available to the city, the Ludlow sources, developed as proposed and supplemented by the use of the Twelve Mile Brook and Scantic River, seem to be in all respects the least desirable.

So far as can be judged from the information concerning the various sources now available to Springfield, the only way in which there might be economy in the further development of the Ludlow sources would be in securing some other source to supplement Ludlow, possessing greater advantages than the Twelve Mile Brook and the Scantic River. The best source in the neighborhood of Ludlow, and probably the only source from which it might be practicable to secure water of good quality and in larger quantity, is the Swift River; and it is possible that that source might be used to supplement Ludlow Reservoir and its tributaries, developed as proposed by the special commission, and a sufficient supply secured in this way to last the city of Springfield for a long time in the future, at less expense than by the use of the Twelve Mile and Scantic streams, as proposed. By this plan, however, it would still be necessary to use the water of Ludlow Reservoir, treated by double filtration.

When considering the Ludlow sources, it is necessary to recognize the fact that no water of this character has been used by any city and made satisfactory by any method of treatment. If it were impossible, or even extremely difficult, to obtain a source of better water, the experiments which have been made here would point a way for rendering this water much better than it is, and perhaps make it satisfactory; but while good water is available at no greater, and possibly at less, expense, the Board cannot advise the continued use of these sources; and the only reason in the view of the Board for further consideration of these sources is to present to the city a full statement of the facts concerning the condition of these sources and of the works by which the water is supplied, in order that the city may fully understand the extent of the work that would be required for the further development of a water supply from the Ludlow system, and the impracticability of obtaining an adequate supply of water of good quality from these and the proposed auxiliary sources for the future use of the city at the cost indicated in the plans and reports now under consideration; and this information might have value in making a fair comparison of the cost of developing a supply from these sources with the cost of works for securing water from some of the other sources available.

In the opinion of the Board, it is impracticable for the city of Springfield to determine satisfactorily, with its present information, which of the sources that are still apparently available would be the most economical and in other respects desirable for the city to adopt, and further investigation is necessary. The sources which appear to the Board to be

most worthy of further consideration by the city are the tributaries of the Westfield River, especially the east and middle branches considered separately, and the Westfield Little River; and the Board would advise the city to proceed with a thorough investigation of these sources, having in view present needs as a basis for probable future requirements, and each of the sources mentioned should receive careful consideration.

The investigation of the various sources which now appear to be available should be made with the assistance of an engineer of experience in matters relating to water supply, and the work should be done carefully and thoroughly, so that the facts presented may be reliable and the information obtained sufficiently complete to furnish a reliable basis for estimating the probable cost of works for supplying the city with water from the various sources considered, and to furnish reliable information as to the probable yield of the works and the probable quality of the water.

MAY 18, 1905.

To the Board of Water Commissioners of the City of Springfield.

GENTLEMEN: — In response to your request of May 12 for the advice of the Board as to the use of Loon Pond as a source of additional water supply for the city of Springfield, the Board has caused an examination of the pond to be made, and has considered the results of chemical analyses of numerous samples of this water which have been sent in by you at frequent intervals since 1896.

The results of the analyses show that the water of this pond is of about the same character as that of Five Mile and Chapin ponds. It has been affected occasionally, as have the waters of the other ponds, by the presence of microscopic organisms which impart to the water a disagreeable taste and odor; but except when affected by such organic growths, its water is of good quality for drinking and other domestic purposes.

The pond is situated near Five Mile Pond, in the large sandy plain east of Springfield; and, while the limits of its water-shed are indefinite, its area is apparently less than half a square mile, and the quantity of water obtainable from it is limited. Its use, however, will aid considerably in supplying the city at times when the water of Ludlow Reservoir is objectionable; and, in the opinion of the Board, it is an appropriate source to use under these conditions as a temporary source of supply until such time as an adequate quantity of water has been obtained for the city from some suitable source.

JULY 12, 1905.

To ELBERT E. LOCHRIDGE, Esq., *Water Department, Springfield, Mass.*

DEAR SIR: — On July 6, 1905, the State Board of Health received from you a request for the Board's advice concerning the use of copper sulphate in the Ludlow Reservoir this summer, in order that, in the event

of an inadequate supply from Five Mile and Chapin ponds and from Loon Pond, the water of that reservoir (in which it is stated *Anabæna* appeared in June) may be drawn upon.

In reply, I beg to inform you that the Board is continuing its experiments with copper sulphate, but its experience has not yet convinced it that the use of that substance in drinking water is advisable or free from danger.

Springfield (Springs).

Oct. 5, 1905.

To the Board of Health of the City of Springfield, **Herbert C. Emerson, M.D.,** *Clerk.*

Gentlemen: — In accordance with your request, the State Board of Health has caused an examination to be made of the Iroquois, Massasoit, Wilbraham Mountain and Hygeia springs, and of a spring and well near Walnut Street, and has caused samples of their waters to be analyzed.

The results of the examinations do not show that any material change has taken place in the surroundings of the Massasoit, Wilbraham Mountain or Hygeia springs, nor do the analyses show that a material change in the quality of the waters of these springs since the examination of last year has taken place. The water of the Iroquois Spring was of poorer quality than when last examined, and contained a larger number of bacteria than usual, including bacteria characteristic of sewage. The Board would advise that the use of this source be discontinued, unless such measures are taken for its protection as satisfy you that the water may safely be used.

The waters of the Ackerman well and the spring near the house occupied by Mrs. George Hancock are both very badly polluted, and the Board would advise that their further use be discontinued.

Stoughton.

Oct. 5, 1905.

To the Board of Water Commissioners of the Town of Stoughton.

Gentlemen: — The State Board of Health has considered your application for advice as to a proposed plan of improving the water supply of the town of Stoughton by changing the present intake from Muddy Brook to a point about 600 feet farther up stream, and above a swamp through which Leonard's Brook overflows at times into Muddy Brook, and the Board has caused the locality to be examined by its engineer and samples of the water to be analyzed.

The plan is similar in its general features to a plan presented for the consideration of this Board on Aug. 15, 1899, the object then, as now, being to secure water of better quality by taking the water of Muddy Brook above Leonard's Brook, since it is believed that the high color and

the objectionable taste and odor noticeable at times in the water supplied to the town are due chiefly to the water of Leonard's Brook.

An examination of the analyses of the water of Muddy Brook and its tributaries shows that the water of Leonard's Brook at times of high flow has probably a higher color and contains a greater quantity of organic matter than the water of Muddy Brook.

The flow of Leonard's Brook apparently fluctuates greatly, and the stream is said to be wholly dry at times in summer, so that it is of little value in connection with the present system of water works. The flow of Muddy Brook, on the other hand, is exceptionally constant, on account of the steady flow from the large springs about Muddy Pond; but the spring water, though excellent in quality as it flows from the ground, deteriorates greatly after storage in Muddy Pond and contact with organic matter in the swamps about it; and, while the water of Leonard's Brook is undoubtedly at times more highly colored and contains a greater quantity of organic matter than that of Muddy Brook, there is no doubt that while the water supply of Stoughton continues to be taken from Muddy Brook it will be affected at times by a high color and an objectionable taste and odor, even though the intake should be changed to a point above Leonard's Brook.

The town of Stoughton has been advised many times that a water supply of excellent quality can with little doubt be obtained by collecting the spring water which now finds its way into Muddy Pond and into Muddy Brook below the pond; and, if the changes which are necessary in the present collecting works in order to make it possible to utilize this spring water should be made, the town would not only avoid the necessity for using water having an objectionable color, taste and odor, and secure instead a spring water of excellent quality, but would also avoid the danger of pollution, to which the present source is necessarily exposed.

The proposed new conduit, so far as the plans presented show, will not aid materially in accomplishing these objects, and it is unwise, in the opinion of the Board, for the town to make further outlay upon its sources of water supply until the practicability of obtaining an adequate ground-water supply in this valley has been ascertained, — of which there seems to be little doubt, provided the apparently excessive waste of water by leakage from the pipe system in the town can be restricted.

The cost of the necessary investigations and the preparation of plans for the work should not be large, and when this is done the town will be in a position to build the works in sections, if it so prefers, using, if then thought desirable, a temporary intake from Muddy Brook at or near the point now proposed, without the possible necessity of reconstructing a portion of the works.

The Board is informed that it has recently become the custom in

Stoughton to use lead or lead-lined pipe for services, and that at the present time somewhat more than 20 per cent. of the service pipes in use in the town are of lead or are lined with lead. In view of the danger to health in the use of water drawn through lead pipes, the Board has caused an examination to be made to determine what effect the present water supply has upon the lead or lead-lined pipes. The results of the examination show in all cases that the water dissolves lead when flowing through lead or lead-lined service pipes, the quantity dissolved being large enough in some cases, after the water has been standing in the pipes for a few hours, to cause serious injury to health.

In the experience of the Board, the action of such waters as that of Stoughton upon lead service pipes is liable to increase; and, under the circumstances, the Board would advise that the further use of lead for service pipes be discontinued, and that the lead pipes now in use be replaced with pipes of other material.

STURBRIDGE.

APRIL 6, 1905.

To Mr. H. D. HAYNES, *Sturbridge, Mass.*

DEAR SIR: — In response to your request for an examination of the water now used to supply several dwelling houses in the village of Sturbridge, to determine what action, if any, this water has upon lead pipe, and as to the advisability of using lead pipe in connection with a proposed new well, in case the present source does not supply sufficient water for a new public drinking fountain which it is now proposed to construct, the Board has caused the sources of supply to be examined and samples of water from the sources now used to be analyzed.

The well and tributary wells from which the present supply is drawn are located remote from buildings, and do not appear to be exposed to danger of sewage pollution. The analyses of water from these sources after passing through lead pipes of different lengths show that this water takes up lead from the pipes. While the quantity of lead taken up in this way is small at the present time, and might not, when the water is running constantly, be sufficient to cause injury to health, this water may at other times take up a greater quantity of lead than was found to be the case at the time the examination was made. In case the quantity of water supplied from the present source should not be sufficient, and water should be introduced from some other source, this water might take up lead in even greater quantities than is taken up by the water now used.

Considering the circumstances, it is advisable, in the opinion of the Board, to avoid the use of lead pipe. Pipes of tin, or of iron lined with tin, or iron lined with cement, when properly made, may safely be used,

and will not have an unfavorable effect upon the quality of the water which passes through them.

The Board has also caused an examination to be made of the water of your well in the village used for the supply of several tenements, and finds that, while this water has been considerably polluted before entering the well, and contains a larger quantity of organic matter than is usually found in a good well water, it is probably at the present time safe for drinking. In providing a further water supply for the village, it is desirable to secure a sufficient quantity of water to supply all of the houses requiring water for domestic purposes, including those using water from this well. Unless a new supply shall be provided, the water of this well should be examined from time to time, and if any deterioration occurs, its further use should be prevented.

Uxbridge.

Feb. 2, 1905.

To the Board of Selectmen of the Town of Uxbridge.

Gentlemen: — The State Board of Health has considered your communication, received January 23, requesting this Board to approve the use of a well or reservoir on the Crony Brook land, so called, as a temporary source of water supply, until such time as the town by vote shall cause to have built and put in running order the new water supply system now in contemplation; and the Board has also considered the other communications relative to this matter, received on the same date, including the communication of your attorneys, Messrs. Dodge & Taft, suggesting that approval of the source mentioned for temporary use by the town be made under the provisions of chapter 225 of the Acts of the year 1904.

The Board has carefully considered these communications, and the conditions affecting the public water supply of the town of Uxbridge. The present source of supply has repeatedly proven inadequate to furnish the quantity of water required by the town, and water has been drawn in past years from a polluted well near the Mumford River. The Board having called attention to the danger of the use of water from that source, it appears that the town voted last year to take water from the well or reservoir on the Crony Brook land, which had formerly been used at times, and from which water can be diverted by gravity into your present sources of supply.

This auxiliary source has been examined by direction of the Board, and the water has been found to be of good quality; but the quantity of water that can be supplied from your present sources, including this auxiliary source, would usually be insufficient to supply the quantity of water required by Uxbridge in the drier portion of the year, and under

the circumstances the Board does not approve this source under the provisions of chapter 225 of the Acts of 1904.

Your recent investigations have shown that it is practicable for the town to secure a good water supply in ample quantity and at reasonable expense by building works for collecting ground water from the region in which the recent tests were made; and it is of the greatest importance, in the opinion of the Board, that the construction of works for supplying water from this source should be pushed as rapidly as possible. It will, of course, take some time to construct the necessary works, and in the mean time it may become necessary to supplement the present sources with some auxiliary supply.

Under these circumstances, it would be reasonable, in the opinion of the Board, for the town to use the water of the well or reservoir on the Crony Brook land; but it appears to the Board that the approval of the use of this well or reservoir would have to be made under the provisions of section 35 of chapter 25 of the Revised Laws, and not under chapter 225 of the Acts of the year 1904, as suggested. The former law, however, limits the time of taking a temporary supply from any brook, stream, river, lake, pond or reservoir, to a period of not more than six months in any one year. It is understood that the proposed temporary source is not required for use at present, and that it is unlikely that an additional supply will be required before next summer. Since it seems to the Board that approval of the proposed temporary source must be made under the provisions of chapter 25, section 35, of the Revised Laws, which limits the use of a temporary source to six months in any year, it is not desirable, in the opinion of the Board, that action should be taken before dry weather begins next summer, in order that, in case the use of the well or reservoir on the Crony Brook land becomes necessary, it may be available in the drier portion of the year. The Board will, therefore, lay the matter on the table for the present, and will take it up for action at a future time, if you so request.

WALTHAM.

DEC. 7, 1905.

To Hon. JOHN L. HARVEY, *Mayor, Waltham, Mass.*

DEAR SIR: — The State Board of Health received from you on October 20, 1905, a plan of a proposed well to be used as an additional source of water supply by the city of Waltham and a communication containing the following outline of proposed works for enlarging and protecting the purity of the water supply of the city: —

I forward to you a plan and profile of proposed well and pipe line for our water works. It is intended to carry the pipe line the short distance where it crosses water on piles. The shallow pond near the proposed well, and close to which is

test well No. 7, will be thoroughly cleaned out down to the gravel and filled with good material coming from the well. It is intended also, I believe, to do some filling in the channel cut across the neck of the peninsula on which the proposed well is marked.

The location of the proposed well, though not absolutely satisfactory, appears to be, on the whole, the best location we can obtain, taking into consideration its distance from the Roberts district, where cesspools have been located, the fact that it is upon our own reservation, and that it can be constructed here without disproportionate expense.

The location at South Street turned out to be unadvisable, by reason of the fact that we did not get as large a supply of water as we hoped for in the test, joined to the fact that it transpired that settlement with the owner of the location would be very expensive. There was also danger from sewerage to be considered there, for, as we did not get as much water as we anticipated from a small area, we might have to extend the works into an area already contaminated, with consequent large expense for protection.

There has been appropriated by the city $28,000 for sinking the well and constructing a pumping plant to lift the water into the leading main and for laying the leading main.

There has been appropriated $31,000 for the construction of a covered reservoir close to our present reservoir but at a grade enough higher to increase the pressure about 20 lbs.

$21,000 has been appropriated to construct a sewer from the Roberts district for the protection of the water supply.

It is planned to proceed at once with the construction work of the scheme. We shall also proceed with the study of the problem of sewerage for the Crescent Park region. It will be necessary to build a sewer here for the further protection of the water supply. This is in accordance with recommendations made by your Board and is also in accordance with recommendations made by local officers.

The proposed new well is located about 1,100 feet west of your present well, upon a small island adjacent to the northerly bank of the Charles River, the location of the well being near the center of the island, about 160 feet from its northwesterly and southeasterly shores.

The probable quality of the ground water on the island is indicated by the results of the analyses of four samples, two of which were collected from a test well at the site of the proposed collecting well, in September and October of the present year, and the other two in April, 1904, from a test well known as well No. 7, located on the island, about 100 feet from the proposed new well. The results of these analyses show that the water of the new test well is of good quality; but the quantity of iron present was larger than is found in a good ground water, while the quantity of iron present in the water of well No. 7 was so large as to affect slightly the appearance of the water. Considering these results and the circumstances of the location, it is very doubtful whether water of good quality can be obtained here, if a large quantity of water should be drawn from the ground in this locality.

Observations of the height of water in test well No. 7, during the months from August to November, 1902, show that the average level of the ground water on the island during this period was about 1.34 feet below the average level of the water in the river, showing that the ground water near the location of the proposed new well is already greatly affected by the pumping from your present source.

Under the circumstances, it would be impracticable, in the opinion of the Board, to enlarge materially your supply of water or relieve very greatly the draft from the ground about your present source by constructing the proposed new well; and, since it is probable also that the quality of the water would become objectionable for domestic use, the Board does not advise the adoption of the plan now proposed for enlarging and improving the water supply of Waltham.

The only practicable way of obtaining a large additional supply of ground water and relieving materially the draft from the present source is to extend the collecting works into regions in which the ground water is not noticeably affected by pumping from your present collecting well. The observations upon the height of water in test wells driven at various points along the river show that the ground water is affected for a long distance up stream by the pumping from the present collecting well, but the ground water from the neighborhood of South Street still finds an outlet into the river.

The results of a pumping test made about a year ago by pumping continuously from a group of test wells in this locality showed that water of good quality could be drawn freely from the ground here; and it is probable that, by extending the collecting works farther up stream from this place, and putting in more permanent works at a lower level, a considerably larger quantity of water could be obtained than was pumped during the test, and a material reduction made in the draft from the present source. While it is uncertain to what extent such a reduction in the draft of water from the present source would affect its quality, there appears to the Board to be no other way by which further deterioration in the quality of the water can be prevented.

The plan of developing a ground-water supply from the neighborhood of South Street should not be undertaken, however, until the probable cost of the works, including the cost of protecting the purity of the water, has been carefully estimated and compared with the probable cost of obtaining a supply of water from the other available sources.

The Board will, upon application, give you further advice as to any plans you may wish to present, either for developing a ground-water supply in the region near South Street or taking water from some other source.

Waltham (United States Watch Company).

April 6, 1905.

To the Board of Health of the City of Waltham.

Gentlemen: — In response to your request, the State Board of Health has caused an examination to be made of two wells on the grounds of the United States Watch Company in Waltham and has caused a sample of the water of each of the wells to be analyzed.

The water of the deep tubular well, while showing some evidence of previous pollution, would probably not, in its present state, be unsafe for drinking; but this water is hard and contains an excessive quantity of iron, making it an undesirable drinking water. The water of the large well, which is about 12 feet square and 16 feet deep, also shows some evidence of previous pollution, but at the time the examination was made was probably safe for drinking.

The wells are located in a thickly populated part of the city, and the water of such wells is liable to deteriorate after a longer or shorter period of use. If the use of the waters of these wells is to be continued, they should be examined from time to time, in order that if any deterioration occurs their further use may be prevented.

Waltham (American Waltham Watch Company).

Dec. 7, 1905.

To Mr. Royal Robbins, *Treasurer, American Waltham Watch Company, Waltham, Mass.*

Dear Sir: — In response to your communication of Oct. 21, 1905, stating that you are thinking of buying a certain spring located upon Bear Hill in Waltham, intending the water for distribution in your factory for drinking purposes, and requesting the advice of the Board as to its quality, the Board has caused an examination of the so-called spring to be made by one of its engineers and a sample of the water to be analyzed.

The source indicated is a well 6 inches in diameter and said to be 104 feet in depth, situated near the bottom of Bear Hill. The well appears to have been sunk for most of its depth in rock, which was encountered within 6 or 7 feet of the surface of the ground. There are several dwelling houses, with sink drains and other sources of pollution, at no great distance from the well, and the results of the analysis of a sample of the water show that it has been highly polluted. In the opinion of the Board, the water is unsafe for drinking.

Wareham (Onset).

Oct. 5, 1905.

To the Board of Health of the Town of Wareham.

Gentlemen: — The attention of the State Board of Health having been called to the use of water from certain wells used by occupants of cottages on the camp grounds of the Onset Bay Grove Association, which, it is alleged, are exposed to pollution by sewage, the Board has caused the locality to be examined and samples of the water from three of the wells there to be analyzed.

Two of these wells are located on the camp grounds between Highland Avenue and Union Avenue, and the third near the corner of Waban Avenue and Park Street. There are several possible sources of pollution near the wells, and the analyses show that the waters of all three sources have been seriously polluted and not thoroughly purified before entering the wells. In the opinion of the Board, these wells are unsafe sources of drinking water.

Westborough (Insane Hospital).

June 2, 1905.

To the Trustees of the Westborough Insane Hospital.

Gentlemen: — The State Board of Health received from you on May 6, 1905, a communication outlining a proposed plan of water supply for the Westborough Insane Hospital, as follows: —

Our Board of Trustees of the Westborough Insane Hospital, after careful consideration of the subject of an additional water supply, have concluded to request an appropriation from the Legislature to enable us to obtain our drinking water from the Westborough town supply. We are assured by the commissioners of the town of Westborough, in writing, that they can deliver 40,000 gallons per day of good drinking water, at an expense of five cents per thousand gallons, which can be delivered into our small tank without pumping. This will give an ample supply for the ordinary domestic purposes. We shall also extend our pipe farther into Lake Chauncey, in order to reach deeper and cleaner water, which we shall pump into our large tank to supply our laundry, boilers and fire service. Our pipes are already arranged so that the water for drinking purposes can be kept distinct from the lake water. This supply can be obtained by the expenditure of a very small amount of money in comparison with the amount required to connect with the metropolitan water aqueduct, filter the lake water, or to obtain an independent supply from the Hopp and Bummett brooks, and has commended itself to our Board, to Dr. Copp of the State Board of Insanity, and the legislative committee on public charitable institutions. We hope that it will commend itself to your Board also.

In response to this application, the Board has examined Sandra Pond, the present water supply of the town of Westborough, and has considered the proposed plan of using this water for drinking and cooking in the

hospital, and the water of Chauncy Pond for laundry, boiler and fire service, and the possibility of obtaining a water supply for the hospital in other ways.

If the plan now proposed should be carried out, a double system of water supply would be continued, as at the present time. The use of a double system of water supply is objectionable, especially in a hospital like that at Westborough, where the water of one of the systems is unsafe for drinking, as you have already been advised in a previous communication.

It appears from a recent report of the trustees of the hospital that the lake water is not clean, and is becoming worse for laundry purposes; and it is unlikely, in the opinion of the Board, that any material improvement in the quality of the water can be obtained by extending the pipe further into the lake, or by any plan of taking water from this lake, unless the water should be filtered. If the use of Chauncy Pond as a source of water supply for the hospital is to be continued, it will be essential to have it protected from pollution by those who at present use the pond and its shores as a pleasure resort; and such protection can only be secured at considerable expense and possibly at the sacrifice of much of the present use of the shores by the inmates of the hospital.

The water supply of Westborough, from which it is proposed to obtain a drinking-water supply for the hospital, is drawn from Sandra Pond, so called, which is divided into two basins. The upper basin is a shallow storage reservoir, formed by flooding a swampy area to a maximum depth of about 11 feet. The soil, stumps and organic matter were not removed from the area flowed, and the water of this basin is affected by growths of organisms in the summer season and is very objectionable at times for drinking. All about the upper basin the soil is very coarse and porous, and a large quantity of water leaks from this basin and escapes down the valley. The lower basin receives much of the water which leaks from the upper basin through the coarse and porous soil by which it is surrounded, together with ground water from the adjacent territory. This water as it enters the basin is of excellent quality, but upon exposure to light in the basin its quality deteriorates rapidly, and the water becomes affected by large numbers of organisms and the objectionable tastes and odors which they produce. The water of the source is not exposed to serious danger of pollution, and it is not known that the organic growths are injurious to health; but this water would at times be unpalatable, and if introduced into the hospital there would doubtless be times when the Chauncy Pond water would be preferred by the inmates for drinking.

If the town of Westborough should build works in the neighborhood

of the present basins which would collect ground water without exposure to light, there is little doubt that an ample supply of water for the town and for all uses in the hospital could be secured, which would be of excellent quality at all times for drinking, and this would be a good plan for securing a water supply for the hospital; but under present conditions the quality of the water would at times be objectionable, and it would be better for the hospital to take water from some other source.

It is possible that a sufficient supply of good water can be obtained from the ground in the neighborhood of Chauncy Pond by means of wells or similar works; but further tests would be necessary to determine whether a sufficient supply of water can be obtained in this way. The investigations which you have already made indicate that an ample supply can be obtained from the valley of Bummett Brook probably at less expense than from the metropolitan water works aqueduct, as proposed last year.

Unless satisfactory arrangements can be made with the town of Westborough to supply the hospital with ground water of good quality, which has not been exposed to light, the best plan of obtaining a water supply for the hospital would probably be to take water from the ground near Chauncy Pond, if enough good water can be obtained by means of wells or similar works; and the Board would advise a further test with a view to obtaining water in this way. The most favorable localities for such tests are found on the easterly and southerly shores of the pond. If, as a result of these further tests, it is not found practicable to obtain a sufficient ground-water supply for the hospital in this locality, it would probably be best to take water from the ground in the valley of Bummett Brook, if authority to do so can be obtained.

Westfield.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on May 4, 1905, for preventing the pollution and securing the sanitary protection of the waters of Moose Meadow and Tillotson brooks and their tributaries, used by the town of Westfield as sources of water supply.

Nov. 2, 1905.

To the Board of Water Commissioners of the Town of Westfield, Mass.

Gentlemen: — Early in the present year the State Board of Health received a request from the board of health of the town of Westfield that rules and regulations be adopted by this Board for the protection of the purity of the town's water supply; and in accordance with this request the Board caused the water-sheds of the sources of supply to be exam-

ined by its engineer, and on May 4, 1905, adopted rules and regulations for the protection of the sources, under the provisions of the Public Statutes.

The examination made at that time showed that very objectionable conditions existed on Tillotson Brook in Granville, where, in several cases, privies were found in close proximity to the brook or its tributaries, and it was evident that the stream was also receiving foul drainage from barnyards and sink drains. A recent examination of the water-shed of Tillotson Brook shows that the stream is still greatly exposed to danger of pollution from privies, sink drains, etc., at several places.

These conditions are a great menace to the health of those who use this water for drinking, and the Board would urge that action be taken without delay to prevent further danger of the pollution of the water supply of the town from such places.

WESTFIELD (MILITIA CAMP).

JULY 3, 1905.

TO WILLIAM C. DEVINE, M.D., *Surgeon-General, State House, Boston.*

SIR: — In response to your request of June 21 for information in regard to the water supply of the militia camp at Westfield, which you propose to take from a pipe line of the city of Holyoke, which conveys water from the Manhan River to Ashley Pond and the high-service reservoir of that city, the State Board of Health has caused an examination of the water-shed of the Manhan River to be made by one of its engineers, and appends hereto the latest analyses of the water.

These analyses show that the water, while somewhat colored, does not contain an excessive quantity of organic matter, and is soft and in other respects of good quality for water supply purposes.

The water-shed of the Manhan River drains an area of about 13 square miles, and is very sparsely populated. Some of the farm buildings within the water-shed have been purchased by the city, and are no longer occupied; but a few still remain, from which it is possible under some conditions that the water may be polluted. Under the conditions of the use of this stream by the city of Holyoke, constant inspection has not been deemed essential, owing to the fact that the water is stored for a long time either in Ashley Pond or the large high-service reservoir before being supplied to the city; but the Board would advise that during the time of its use at the camp the source be carefully inspected to see that pollution of the water is prevented.

West Island (proposed State Prison).

Oct. 5, 1905.

His Excellency William L. Douglas, *Governor*.

Sir: — The State Board of Health received from you on Sept. 27, 1905, the following application for advice relative to the water supply and climatic conditions of West Island, with a view to its use as a location for a branch State Prison: —

Ordered, That the State Board of Health is hereby requested to make an investigation of the water supply on West Island, and to report to the Governor and Council at as early a date as possible the opinion of the Board relative to the quantity and quality of said water supply; and the Board is also requested to embody in such report a statement as to the climatic conditions and such other features of the island as may properly be considered by the Board in view of the provisions of chapter 106 of the Resolves of the year 1905.

It appears from the topographical map of the State that West Island has an area of upland amounting to a little over 400 acres, and that the highest land upon the island is less than 20 feet above sea level.

The Board has visited and examined the island, and finds that there are no ponds or streams there adapted for use as sources of water supply, and that the conditions are unfavorable for obtaining water from the ground in such quantity as would be required for the proposed State Prison. Moreover, an examination of the adjacent mainland shows that there is no available source of water supply within several miles of the island.

Wilmington (Walker School).

Nov. 2, 1905.

To the School Committee of the Town of Wilmington, Mr. W. G. Frazee, *Secretary*.

Gentlemen: — In response to your request of Sept. 30, 1905, for an examination of the drinking water of the Walker School in Wilmington, and advice as to its quality, the State Board of Health has caused the well from which the supply is drawn to be examined and a sample of its water to be analyzed.

The results of the analysis show that the water contains a somewhat larger quantity of organic matter and a larger number of bacteria than are found in good ground waters. While the water of this well may not be unsafe for drinking in its present state, it would be better, owing to the nearness of the new privy vaults, to construct a well outside of the school building and at a greater distance from possible sources of pollution.

Ice Supplies.

The following is the substance of the action of the Board during the past eleven months in reply to applications for advice relative to sources of ice supply: —

Chicopee.

July 28, 1905.

To the Board of Health of the City of Chicopee.

Gentlemen: — In accordance with your request of June 20, 1905, for an examination of the water of two small streams in Chicopee, upon which it is proposed to construct ice ponds, the State Board of Health has caused the sources to be examined and samples of their waters to be analyzed.

One of the proposed sources is a small stream south of Prospect Street, upon which it is proposed to construct a dam a little over half a mile northeast of the Willimansett Railroad station. The other is a small stream east of Granby Road, about half a mile south of Gratton Street, which flows into the Chicopee River from the north about a quarter of a mile below Chicopee Falls. Both streams are formed by springs flowing from the adjacent portions of the high sandy plain which extends through this region, and upon which there are a few scattered farm-houses and outbuildings; but, as the soil is porous, polluting matters are probably well purified before entering the streams.

It is probable, in the opinion of the Board, that ice of good quality for domestic purposes could be obtained from ponds constructed on these streams as proposed, provided the ponds from which the ice is taken are made of sufficient depth, so that foreign matter from the bottom or sides of the ponds will not be included in the ice when formed.

Dartmouth.

June 2, 1905.

To Messrs. Waite and Smith, *South Dartmouth, Mass.*

Gentlemen: — The State Board of Health has caused an examination to be made of the waters of two small ponds, one on the easterly and the other on the westerly side of the Salter's Point Road north of Nonquitt, in the town of Dartmouth, and samples of water and ice collected from these ponds to be analyzed.

The results of the analyses show that the ice from both ponds contained a somewhat larger quantity of organic matter than is usually found in good ice, due possibly to matters floating upon the pond when the ice was formed, or to the taking up of organic matter from the bottom. The ponds are quite shallow, and there is a group of buildings on the water-shed of each. Polluting drainage from these buildings does

not appear to find its way directly to the pond in either case, and could readily be diverted. If this should be done, it is probable that ice which may safely be used for domestic purposes can be obtained in the future from these ponds, provided that you remove from the ice, after harvesting, the first inch that formed upon the pond and all ice forming above this first inch, whether by snow or flooding, and by rejecting all ice containing particles of foreign matter. Ice should not be harvested from the shallower portions of either pond where matters from the bottom are liable to become entangled in the ice.

Holyoke.

April 6, 1905.

To the Board of Health of the City of Holyoke.

Gentlemen: — In response to your request of March 3, 1905, the Board has caused a further examination to be made of Bray's Pond, a source of ice supply in Holyoke, and has caused samples of the water and ice to be analyzed.

An analysis of the water of the pond shows evidences of somewhat greater pollution than at the time the previous examinations were made. An analysis of a sample of the ice shows that it contains a larger quantity of organic matter and a much larger number of bacteria than are found in good ice, and its quality is not very different from what it has been found to be at previous times. In the opinion of the Board, ice from this source should not be used where it will come in contact with food or drinking water.

Dec. 7, 1905.

To the Board of Health of the City of Holyoke.

Gentlemen: — In accordance with your request for an examination of Congamond Ponds, so called, in Southwick, and advice as to the use of ice from that source, the State Board of Health has caused the ponds to be examined by one of its engineers and a sample of the ice to be analyzed.

The examination shows that the water-shed of the ponds is very sparsely populated, and the conditions are favorable for obtaining good ice. The sample of ice examined was found to be of good quality. In the opinion of the Board, the clear ice harvested from these ponds under present conditions may safely be used for domestic purposes.

Mansfield.

July 6, 1905.

To the Board of Health of the Town of Mansfield, Mr. Elbridge G. Sherman, *Clerk.*

Gentlemen: — In accordance with your request of June 6, 1905, for an examination of an ice supply in Mansfield taken from Fulton's Pond in that village, the Board has caused the pond and its water-shed to

be examined by one of its engineers and samples of the ice and water to be analyzed.

The results of the analyses do not show that the conditions affecting the quality of ice harvested from this pond are materially different from those existing when this source was examined, five years ago. The water of the pond is polluted by the discharge of the sewage from a considerable portion of the village of Foxborough into one of the streams which feed the pond, and by sewage and manufacturing wastes from factories on or near the streams above the pond. As you were advised at the time the previous examination was made, in 1900, this pond might safely be used as a source of ice supply if it were possible to keep the Foxborough sewage from polluting it, or if the sewage of Foxborough should be purified before being discharged into the stream.

The analysis shows the first inch of ice frozen and the snow ice above to be dangerously polluted, and unfit for use. The clear ice below the first inch might be used if free from foreign matter.

NAHANT.

MARCH 2, 1905.

To the Board of Health of the Town of Nahant.

GENTLEMEN: — In accordance with your request, the board has caused an examination of Brown's Pond in Peabody and Flax Pond in Lynn to be made, with a view to their use as sources of ice supply, and has caused the ice to be examined to determine its quality for domestic purposes.

Brown's Pond is used as a source of water supply by the town of Peabody, and the ice taken from this source was found to be of good quality for domestic purposes.

Flax Pond in Lynn evidently receives much pollution by sewage, and some of the ice harvested from this source consisted largely of snow ice. The clear ice from this source contained considerably more organic matter than that taken from Brown's Pond, while the snow ice contained a larger quantity of organic matter than the clear ice.

It is possible that ice which might safely be used for domestic purposes could be obtained from Flax Pond by removing from the ice, when harvesting, the first inch formed upon the pond and all ice formed above this first inch, including snow ice and ice formed by flooding, and by rejecting all ice containing particles of foreign matter.

WESTFIELD.

FEB. 20, 1905.

To the Board of Health of the Town of Westfield.

GENTLEMEN: — In response to your request for advice as to the quality of the ice taken from Fowler's Pond, Powder Mill Pond, Still Pond, the Westfield River and the Westfield Little River, sources of ice supply

located in the neighborhood of Westfield, the State Board of Health has caused the localities to be examined by one of its engineers and samples of the water and ice from the various sources to be analyzed.

All of the samples collected from the different sources consisted in part of clear ice and in part of snow ice formed over the clear ice by rain or flooding. Except in the case of the Westfield Little River, the clear ice from all of the sources appears to be formed under conditions favorable for the exclusion of foreign matter, though Powder Mill Pond is somewhat shallow and there is danger that matters from the bottom of the pond may be included in the ice when formed. The ice collected from the ice field on the Westfield Little River not far below one of the paper mills contained objectionable bacteria; but it is probable that ice could be obtained from the mill pond on this stream above the upper paper mill which would not differ materially in quality from that of the other sources.

All of the sources are located near the village, and in all cases there is population upon the water-shed of the pond or stream from which the ice is taken.

The Board would advise that ice which may safely be used for domestic purposes can be obtained from these sources by removing from the ice, when harvesting, the first inch formed upon the pond and all ice formed above this first inch, including snow ice and ice formed by flooding, and also rejecting all ice containing particles of foreign matter.

Weston.

July 6, 1905.

To the Board of Health of the Town of Weston, **F. T. Hyde, M.D.**, *Chairman.*

Gentlemen: — Replying to your request of May 20 for advice concerning the quality for domestic purposes of ice taken from the pond of G. A. Foote, near the water works pumping station north of Central Avenue, the Board has caused the pond and its surroundings to be examined and samples of the water and ice to be analyzed.

The results of the analyses show that, while the water is highly colored by contact with grasses, leaves and peaty soil, and contains a considerable quantity of organic matter, it is well protected from sewage pollution at the present time. The ice stored in the ice house near this pond consists chiefly of clear ice, with a layer of snow ice on top of each cake. The clear ice was found upon analysis to contain but little organic matter, and was in other respects of good quality.

In the opinion of the Board, the ice harvested from this source under present conditions may safely be used for domestic purposes; but the Board would advise the removal from ice to be used in contact with food or drinking water of all the snow ice, including the first inch of clear ice formed on the pond.

Sewerage and Sewage Disposal.

The following is the substance of the action of the Board during the past eleven months in reply to applications for advice relative to sewerage and sewage disposal.

Duxbury (Powder Point).

June 1, 1905.

To the Board of Health of the Town of Duxbury.

Gentlemen: — The State Board of Health has considered your request for advice as to the disposal of the sewage from Powder Point, and has caused the locality of the present sewer outlet and the general condition of the bay in this region, and the requirements of the village at Powder Point in the matter of sewage disposal, to be examined.

It appears that the present sewer from the buildings of the Powder Point School, which are used in the summer as a hotel, and usually contain from 75 to 100 people, discharges into a small channel in Duxbury Bay, about 300 feet from the main channel in the bay south of Powder Point; but as the sewer leaks badly, sewage escapes upon the flats at many places along its course. Much of the sewage is also allowed to discharge at all times, causing the pollution of the flats in the neighborhood of the outlet, and under present conditions this outlet is an objectionable one.

The soil in Powder Point is very fine and nearly impervious to water, so that the disposal of sewage by means of cesspools is difficult, and it is impracticable to discharge the sewage upon any land suitable for its purification by filtration without pumping. Under the circumstances, the least expensive method of disposing of the sewage would be to discharge it into Duxbury Bay. There is no doubt that the sewage of the present village of Duxbury, including Powder Point, could be disposed of by discharging it into one of the channels in Duxbury Bay without causing a nuisance or offensive conditions about the sewer outlet or upon the flats of the bay, provided that the sewage were discharged only at the most favorable places and on the latter portion of the outgoing tide; but in the past large numbers of shellfish have been taken from Duxbury Bay, and it is understood that oysters have been grown here up to the present time, and if sewage is to be discharged into the bay, it must be so discharged that it will not affect any waters or areas of flats from which shellfish are taken.

Considering the circumstances, it is advisable, in the opinion of the Board, that an investigation be made to determine the best outlet for the sewer now discharging at Powder Point, with a view to providing for the disposal of the sewage of other places in and about the village; and that for this purpose the various channels in the harbor be examined,

the areas from which shellfish are taken located, and such other information obtained as will make it practicable to select the least objectionable point of discharge. It would be well also to consider the feasibility and probable cost of disposing of the sewage upon land, in case an unobjectionable sea outlet cannot be found.

Any information collected by the engineer of the Board in the course of the examination of the conditions at Duxbury is available to you in making further investigations.

Fairhaven.

March 2, 1905.

To the Sewer Commissioners of the Town of Fairhaven.

Gentlemen: — The State Board of Health received from you on Feb. 28, 1905, an application, under the provisions of section 117 of chapter 75 of the Revised Laws, for the advice of the Board as to the disposal of the sewage of the Oxford sewer district in the town of Fairhaven by discharging it into Fairhaven harbor, in the manner described in your application, as follows: —

> The outfall will consist of 14-inch iron pipe running along the shore westerly in line of extension center of Pilgrim Avenue to a point in the easterly line of West Street extended, thence southwesterly to center line of West Street extended, thence southerly to a point about 300 feet below mean high-water mark at foot of West Street. The pipe will be laid in a trench dug to an approximately true grade in the bottom of the river, so as to cause no barrier to navigation.

The Board has caused the locality to be examined by one of its engineers and has considered the plan submitted.

The sewer outlet, under the plan now proposed, would be located at a point in the harbor where the depth of the water at low tide is about 11 feet; and the Board is of the opinion that the discharge of the sewage from the village of Oxford at this outlet would not be objectionable at the present time.

The outlet should be regarded as a temporary one, to be extended in the future farther from shore if necessity should require, and abandoned entirely if the quantity of sewage discharged at this outlet should materially increase in the future.

Foxborough (State Hospital).

Sept. 7, 1905.

To Charles E. Woodbury, M.D., *Superintendent, Foxborough State Hospital, Foxborough, Mass.*

Dear Sir: — The State Board of Health received from you on Aug. 2, 1905, a communication stating that at the last session of the Legislature a sum of money was appropriated to erect new buildings at the Fox-

borough Hospital, to be used in connection with those already there, both for inebriates and chronic insane persons; and you request to be advised as to whether, in the opinion of the Board, the present sewage filtration area would be sufficient for the purification of the sewage of more than double the present number of persons in the hospital, and, if not, how large an area should be added.

The Board has caused the present disposal works of the hospital to be examined by one of its engineers, and has considered the results of the examinations of these works that have been made from time to time since the hospital was built. From this examination it appears that the area of the present filters is somewhat more than an acre. The quantity of sewage flowing from the hospital to the flush tank and thence to the filter beds amounts to about 25,000 gallons per day; and, in addition to this quantity, there is a large quantity of waste water from the laundry which is discharged upon the filter beds without passing through the tank.

The examinations that have been made from time to time in past years show that, since the filter beds were reconstructed in 1899, under the direction of J. J. VanValkenburgh, C.E., they have operated satisfactorily at all times; and it is possible, in the opinion of the Board, that a somewhat larger quantity of sewage than is now discharged upon these filters could be disposed of on this area without overtaxing the filters or creating other objectionable conditions; but if the population at this institution should be doubled, the quantity of sewage would probably greatly overtax the capacity of the present filter beds; and, in the opinion of the Board, it is advisable, in view of the proposed enlargement, that the area of filter beds be doubled before the new buildings are ready for use.

Haverhill.

Aug. 3, 1905.

To the Hon. Roswell L. Wood, *Mayor, Haverhill, Mass.*

Dear Sir: — The State Board of Health received from you on July 24, 1905, an application for advice as to proposed changes in the sewer outlets discharging into the Merrimack River between Main and Chestnut streets on the north side of the river in the city of Haverhill, in which you give the following outline of the proposed scheme: —

In consideration of certain inducements offered by the Haverhill Electric Company, the city has decided to abandon the present outlet of the Chestnut and School Street sewers now crossing the company's land, and to build a new outlet to the river, through a public landing located farther to the west.

In view of the fact that the several outlets in this vicinity are not now satisfactory, it is proposed to make the new outlet a main outlet, and to eventually concentrate here the dry-weather flow of all sewers between it and Main Street, including

the latter. To this end it is proposed to lay a submerged pipe to the edge of the river channel for the dry-weather flow, and to provide for a 15-inch pipe sewer to be laid westerly in Water Street to Main Street, which sewer shall intercept the dry-weather flow of all sewers now crossing Water Street within these limits, thus eventually doing away with dry-weather discharge from six outlets. The storm flow of the Chestnut and School Street sewers will be discharged through the new outlet at the high-water line in the river, and the storm flow from a small area around Lindel Street and Carleton Court combined with it. No provision is made for the storm flow of the sewers intercepted by the proposed west branch other than their present outlets, it being deemed best to treat each separately as opportunity affords.

The work to be done at present is the construction of the submerged outlet and the portion of the main sewer through the landing and east in Water Street to the junction of the sewers in School and Chestnut streets.

The application is accompanied by a plan showing existing sewers and the works which it is proposed to construct to convey the sewage to the proposed new outlet. This plan is entitled "Plan showing proposed Rearrangement of Sewer Outlets crossing Water St. between Main and Mill Streets, Haverhill, Mass., July, 1905. Robert R. Evans, City Engineer. Scale 100′ = 1″," and was filed in the office of the State Board of Health July 24, 1905.

The Board has caused the locality to be examined by one of its engineers and has considered the plan and information submitted therewith.

By this plan all of the sewage and storm water collected by sewers in Chestnut, School and Lindel streets and a portion of Water Street will be conveyed to the new outlet, and, excepting at times of heavy rain or when snow is melting, will be discharged through the submerged pipe at an outlet located at such a distance from the shore that it will be unlikely to return before it becomes thoroughly diluted by the river water. The excess of flow of mingled sewage and storm water above the carrying capacity of the 16-inch submerged outlet pipe at times of heavy storms may reasonably be discharged at the edge of the stream as proposed without serious danger of creating objectionable conditions, and, if necessary in the future, the outlet can be extended to the harbor line.

The plan also provides for the construction of an intercepting sewer in the future, to intercept the dry-weather flow of sewage from Main, Stage, Green, Moore and Kent streets and Carleton Avenue, and convey it to the outlet now proposed. Nearly all of these outlets are objectionable at the present time; but if the dry-weather flow of sewage were diverted from them, allowing only the sewage mingled with storm water at times of storm to discharge at the present outlets, it is probable that the objectionable conditions which now exist about these outlets would be removed.

The plan is in general, in the opinion of the Board, a satisfactory one for the disposal of the sewage of the district in question and the removal of the objectionable conditions now existing on the shore of the river in this neighborhood.

Holyoke.

July 6, 1905.

To the Board of Health of the City of Holyoke.

Gentlemen: — The State Board of Health has considered your communication of May 26, 1905, requesting its opinion as to whether the overcharging of the Essex Street sewer, so that the sewage flows out upon the street in times of heavy rain, is liable to spread disease, and also as to the desirability of constructing a double sewer system for that street, and has caused the locality to be examined by its engineer.

It appears from the information presented that the Essex Street sewer is well constructed, but it is not now of sufficient capacity to remove all of the storm water and sewage which enters it at times of heavy rains without causing the sewage to rise in some places above the house drains, and occasionally to flow out of one or more manholes upon the street, and that several cases of contagious disease have occurred in houses along this street.

In order to prevent the flooding of cellars, check valves have been installed in the houses along the street liable to be affected by back water from the sewer; but check valves used under such circumstances as these are liable to be inefficient in preventing the flooding of cellars, and the flooding of a street or of cellars of buildings in a thickly populated residential district such as this must be regarded as objectionable and unsanitary.

The Board is informed that the board of public works has already planned to build a storm-water drain for the relief of this and other sewer districts; and, in the opinion of the Board, it is advisable that relief be provided as soon as practicable, so that the further flooding of the street or cellars shall be prevented.

Longmeadow.

April 6, 1905.

To the Board of Water and Sewer Commissioners, Mr. W. F. Emerson, *Clerk, Longmeadow, Mass.*

Gentlemen: — The State Board of Health, in response to your communication of March 8, stating that the lower or southerly sewage-disposal system of the town of Longmeadow was not working satisfactorily, and requesting advice as to a remedy, has examined the plans of the proposed system of sewage disposal for this portion of the town submitted to this Board for its advice on March 2, 1900, and has caused an exam-

ination of the present condition of the filter beds to be made by one of its engineers.

The plans considered by the Board provided for the construction of two filter beds, each 50 feet square and 5 feet in depth, to be constructed of suitable sand and gravel for the purification of sewage. Modifications were suggested by the Board to provide for an automatic dosing tank and for certain changes in the underdrainage and in the elevation of the filters. It appears from the recent examination of the works that the filters were built of smaller size than was proposed in the plans recommended by the Board in 1900, and that most of the sewage has been discharged upon one of the beds, the bank of which has now been washed away so that the sewage flows upon the adjacent lands and finds its way into the nearest stream.

In order to provide adequately for the purification of this sewage, it will be necessary to reconstruct partially the present filters and the pipe leading thereto, and to provide a larger filtration area. Plans should be prepared and the work carried out without unnecessary delay. When you have prepared plans for the improvement of the works, the Board will, upon receipt of the plans, advise you concerning them.

A copy of the advice of the Board relative to the original plans, and of the description of the land which it was then proposed to take for the disposal of sewage and the taking of which was approved by the Board, are enclosed herewith for your information.

The Board would also call attention to the fact that unpurified sewage is allowed to escape from the northerly sewage-disposal area of the town, and to collect in a large stagnant pool near by. The filtration area at this place is evidently ample for the purification of the sewage discharged there, and with a very little care all of the sewage could be passed through the beds and purified, and none of it need be allowed to escape and create the objectionable conditions which now exist at this place.

Marion.

May 12, 1905.

To Mr. William A. Andrew, *Chairman of Selectmen, Marion, Mass.*

Dear Sir: — The State Board of Health received from you on March 20, 1905, an application for advice with reference to a proposed system of sewerage and sewage disposal for the town of Marion, accompanied by plans of the proposed works.

The plans provide for a system of pipe sewers designed to collect the sewage from the thickly settled portion of the village and convey it to a collecting reservoir near the town hall, whence it is proposed to pump it to filter beds to be located about 900 feet west of the town hall and about 300 feet west of Spring Street, where the sewage is to be purified

by intermittent filtration and the effluent discharged into Sippican harbor through a pipe discharging about 200 feet from shore off Silver Shell Beach, so called.

The sewage from a low area near the southerly end of the village cannot be conveyed by gravity to the proposed collecting reservoir near the town hall; and the plans provide for collecting the sewage from this district at a reservoir south of Lewis Street about 500 feet west of Waters Street, whence it is to be pumped into the main sewer of the town at the corner of Allen and Front streets, through which it will flow to the main collecting reservoir.

The plans of the disposal works, as modified in the communication of your engineers dated May 6, provide for two filter beds having a combined area of about one-third of an acre, and a sludge bed having an area of about 800 square feet. The soil at the proposed filtration area appears to be too fine for the purification of sewage by intermittent filtration, and the Board is informed that you propose to construct filter beds of sand to be hauled from the seashore in this neighborhood. The minimum depth of sand in the filters, according to the plans, will be 4 feet, increasing to points nearer the underdrains to a maximum of 5 feet. The embankments around and between the filters are to be constructed of the soil found upon the area.

The Board has caused the locality to be examined by one of its engineers and has carefully considered the plans of the proposed works. The proposed sewers and pumping stations, if properly constructed and operated, will provide satisfactorily for the collection of all of the sewage of the village and for conveying it to the proposed filtration area.

The location of the proposed filtration area is not objectionable from a sanitary point of view. This area is located in the midst of an extensive area of woodland, and while the conditions remain as at present it is unlikely that any odor from the filter beds will be noticeable at any of the dwelling houses in the village.

The area of the proposed filter beds is probably sufficient for the requirements of the village, in the beginning at least; and if the works shall be properly constructed and maintained, they will, in the opinion of the Board, provide satisfactorily for the disposal of all of the sewage of the present village.

SEPT. 7, 1905.

To Mr. WILLIAM A. ANDREW, *Chairman, Board of Selectmen, Marion, Mass.*

DEAR SIR: — The State Board of Health received from you on Aug. 8, 1905, an application for advice with reference to a proposed change in the plans of sewerage and sewage disposal of the town of Marion, accompanied by a report of your engineers, Messrs. Williams & Whitman, giving details of the proposed plan.

The plan now presented provides for the collection of the sewage of the village in the same manner as was proposed in the application presented to this Board earlier in the year, concerning which you were advised in a communication dated May 12, 1905; but it is now proposed to change the location of the filter beds to a place about 800 feet west of Mill Street, near the head waters of a tributary of Doggett's Brook, and approximately 1,000 feet west of the area proposed in the previous plan. Aside from the change in the location, it does not appear to the Board that there is to be any other material change in the plan.

The filter beds are to be built of sand brought to the location, and, according to the plans presented, will cover an area of about one-third of an acre to a depth of at least 4 feet, with a depth of 5 feet over the main underdrain. The effluent from the filters will be discharged into the head waters of a branch of Doggett's Brook, a tributary of the Weweantic River which flows into Buzzards Bay north of Marion harbor.

The Board has caused the location of the proposed filter beds to be examined by one of its engineers and has considered the plans presented. By the change in the plans the filter beds will be located at a greater distance from the village than under the former plan, and, in the opinion of the Board, the location now proposed is a satisfactory one for the purpose; and if the beds are properly constructed and operated, the sewage of Marion can be efficiently purified at this place without causing objectionable conditions.

Oct. 5, 1905.

To the Citizens' Committee on Sewerage of the Town of Marion.

Gentlemen: — On Sept. 15, 1905, the State Board of Health received from you a further application for advice as to a proposed system of sewerage and sewage disposal for the town of Marion, accompanied by plans of the proposed purification works.

The Board is informed that the plan of collecting the sewage is the same in all essential features as the plan previously presented, but the area now proposed for the disposal of the sewage is located at a considerable distance farther from the village than the areas previously considered; and, instead of building the filter beds artificially with sand hauled to the location, it is proposed to utilize the soil found upon the area. The plan of sewage disposal provides for the construction of eight filter beds, having an aggregate area of nine-tenths of an acre.

The Board has caused the locality to be examined by one of its engineers and samples of the soil collected from several test pits on the proposed filtration area to be analyzed. The results show that the soil is in general well adapted for the disposal of sewage by intermittent filtration. The surface soil is fine, and this material should be removed from the

proposed filter beds. The soil in the bottom of the test pits was also found to be as a rule quite fine, making underdrainage necessary.

In the opinion of the Board, the plan in general is a satisfactory one for the collection and disposal of the sewage of the village of Marion; and if the proposed filters shall be constructed in a proper manner, and underdrained, they will make reasonable provision for the purification of the quantity of sewage likely to be discharged upon them.

Northampton.

Feb. 2, 1905.

To Hon. Theobald M. Connor, *Mayor, Northampton, Mass.*

Dear Sir: — The State Board of Health has given further consideration to the request of the city solicitor of Northampton, dated Nov. 28, 1904, for the approval of certain plans for the sewage disposal of the city, and to evidence showing the financial condition of the city with reference to the debt limit; and in view of the circumstances the Board has passed the following vote: —

Voted, That, if the city of Northampton builds during the year 1905 that part of the sewer leading to the Connecticut River from the junction of Wright Avenue and Pleasant Street down to a point 300 feet below Meadow Street, discontinues the discharge of sewage into Mill River and a tributary brook near Wright Avenue bridge from sewer overflows and other sources above a proposed new overflow near Meadow Street, cleans up the channel of the river between the sewer outlet and the Connecticut River, diverts the King Street brook from the sewerage system, thus making a beginning upon the separation of the sewage from the storm water in the city to be carried on in successive years with reasonable diligence, the Board will extend the time for the completion of the sewer to the Connecticut River to Dec. 1, 1910, unless the Board finds it necessary to require the removal of sewage from Mill River previous to that date.

Norwood.

Aug. 3, 1905.

To the Board of Selectmen of the Town of Norwood.

Gentlemen: — The State Board of Health received from you on July 6, 1905, the following communication, requesting a reasonable extension of time within which to carry out measures about to be undertaken to remove from the Neponset River the unpurified sewage from the sewer or drain of the town of Norwood now discharging into that stream near Dean Street: —

By an order of your Board served upon the town of Norwood, the latter was notified to cease discharging unpurified sewage from a certain sewer or drain of the town of Norwood into the Neponset River on and after July 1, 1905. At a town meeting held Friday, June 30, 1905, the town of Norwood voted an appro-

priation of money for the purification of said sewage to comply with the order of your Board, and appointed a committee to immediately proceed with said work. The selectmen of Norwood, therefore, hereby petition your honorable Board for a reasonable extension of time in which to carry out the measures about to be undertaken.

It appears that at a recent town meeting a committee was appointed and an appropriation made for making the plans and doing the work necessary for the disposal of the sewage from this sewer, provision also being made at this meeting for raising additional funds, if necessary.

In the opinion of the Board, if the necessary investigations be carried on with diligence they can be completed and plans prepared within a few weeks, and if the matter shall be pursued diligently and suitable plans presented to the Board before the first of October next, the Board will then grant a reasonable extension for the completion of the work.

DEC. 7, 1905.

To the Committee on Sewerage of the Town of Norwood, MR. FRED. L. FISHER, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on Nov. 22, 1905, a plan and report of your engineer, outlining a proposed scheme for purifying the sewage of the town sewer now discharging into the Neponset River near Dean Street.

The plan provides for the construction of two acres of filters, divided into eight beds, upon land near the present sewer north of Dean Street. Test pits, dug in various parts of this area, show that the soil, beneath a deep layer of loam and subsoil, consists of coarse and porous gravel. It is proposed to remove the loam and subsoil and discharge the sewage upon the gravel, and to collect the effluent in underdrains, which are to discharge into the brook near by. The elevation of the land is not greatly above the level of the brook, and the depth of the filtering material above the underdrains will be about 3 feet. The sewer at the point where it reaches the filtration area is about 8 feet below its level, and it is proposed to allow the sewage to back up in the sewer to a sufficient height to discharge upon the filters. A part of the sewer consists of a wooden box, and it is expected that there will be a considerable leakage if the sewer is backed up as proposed, and the plan provides for replacing the wooden box with a tile pipe sewer wherever serious leakage occurs.

Measurements of the flow of sewage from this sewer during the recent dry weather show that the quantity amounted to about 100,000 gallons per day. It is evident, however, that in wet weather the quantity is much larger.

The Board has caused the locality to be examined by its engineer and has considered the plan submitted. The location of the proposed filter

beds is at such a distance from the village and from dwelling houses that its use for the purpose now proposed is unlikely to be objectionable for the present at least.

The plan has several objectionable features, the most important of which are the comparatively slight elevation of the filters above the level of the brook, the shallowness of the filtering material, and the danger of the escape of a large amount of unpurified sewage by leakage from the sewer when the outlet is raised to the surface of the beds, and the liability of clogging in the depressed part of the sewer; and the necessity of removing some of these objectionable features may entail a larger expense than is now expected, since, if the sewer should leak badly or become clogged, or the filter beds should not operate satisfactorily, it may be necessary to rebuild a considerable portion of the sewer and to raise the level of the filter beds by filling.

In the opinion of the Board, it is desirable for the town to abandon the present sewer and construct without delay a sufficient portion of the proposed sewerage system of the town to dispose of the contents of this sewer. The Board, however, approves the plan for the temporary disposal of the sewage upon the proposed filtering area, with the understanding that the level of the filter beds shall be raised if necessary; and provided, also, that the use of this area for sewage disposal shall be discontinued when a sewerage system for the town shall be constructed.

The Board hereby extends the time for the removal of the sewage of the town sewer from the Neponset River and its tributaries to July 1, 1906.

Norwood (Winslow Bros. & Smith Company).

Aug. 3, 1905.

To the Winslow Bros. & Smith Company, Norwood, Mass.

Gentlemen: — The State Board of Health received from you on July 7, 1905, the following communication, requesting an extension of time within which you shall be required to operate a complete system of filter beds for the purification of the sewage and manufacturing waste now discharged from your works at Norwood into Hawes Brook: —

I beg to report that we are now operating the system of settling tanks installed at our Winslow plant, and we should judge that these basins were taking care of the greater part of the sewage which comes from our plant.

Owing to a misunderstanding, we did not know that we were also expected to have a portion of our filtering system in working order at the time of starting the settling tanks, so that this work has not been completed. We regret the delay, but understood that this matter could lie open until some action was taken by the town, when it would be decided whether we would combine with them in the use of such filtering beds as they installed, or whether we should have an independent system of our own. Our present opinion is that our interests will be better served

by installing our own system, and it is agreeable to us to begin work within a reasonable time upon these beds of our own.

We feel sure that the work which has already been done removes the greater part of the pollution from our stream, and that from now on we will have no difficulty in keeping well ahead of our neighbors as regards the purity of whatever waters come from our Winslow plant. We therefore hereby make an application for an extension of the time in which we shall be required to operate our complete system of filter beds, and hope that in view of the above you will see your way clear to grant it.

It appears that the settling tanks provided for in the plans presented to and approved by this Board last year have already been completed, and the Board is informed that steps have been taken to begin without delay the construction of the filter beds forming an essential part of the plans for the purification of the wastes from these works.

The Board hereby extends the time for the completion of four acres of the filter beds to Dec. 1, 1905; and for the completion of the remaining portions of the works required under the order of the Board of Aug. 10, 1904, to July 1, 1906.

ROCKLAND (E. T. WRIGHT & CO.).

SEPT. 7, 1905.

To the Board of Health of the Town of Rockland.

GENTLEMEN: — The State Board of Health received from you on Aug. 9, 1905, a communication requesting its advice as to the disposal of the sewage of the factory of E. T. Wright & Co. in Rockland, and has caused the locality to be examined by one of its engineers.

It appears from this examination that the factory in question is situated at the corner of Webster and Liberty streets, in the westerly portion of the village of Rockland, and that there are from 400 to 500 hands employed. The sewage is now discharged into a cesspool close to the factory at the corner of Webster and Liberty streets, whence it overflows into the gutter on Webster Street and flows down the street for a distance of 500 feet to the brook leading to Cushing's Pond. A second cesspool is now in process of construction near the opposite corner of the factory and very close to the factory building, and it is understood that it is proposed to provide an overflow from this cesspool into a blind drain laid close to the wall of the factory, for the purpose of removing the drainage and preventing the water from entering the cellars, this blind drain having an outlet into another drain leading to the brook already referred to.

An examination of the soil in which the cesspool is located and of the circumstances controlling the ground-water level in this neighborhood shows that this cesspool will probably not provide for the disposal of the

sewage of the factory, and that sewage will overflow and find its way into the drain, and thence into the brook leading to Cushing's Pond.

It is not practicable, in the opinion of the Board, to dispose of the sewage of the factory satisfactorily upon the very limited area available within the factory grounds, nor does there appear to be any suitable area in the immediate neighborhood of the factory which could be used for the purpose, though it is possible that an area might be found in the neighborhood on which the sewage might be disposed of temporarily until other means are provided.

The best method of dealing with the objectionable conditions existing at this factory and at other localities in this town is to construct sewers for the removal of the sewage to a proper place of disposal, as you were advised in a communication of this Board last year relative to a similar condition of things in another part of the town.

The necessity for sewerage in certain sections of the town of Rockland is urgent, and the Board would advise that steps be taken at once, with the assistance of an engineer of experience in matters relating to sewerage and sewage disposal, in preparing a plan of a general system of sewerage and in the construction of such portions as are necessary to afford relief from the objectionable conditions now existing.

Salem.

Sept. 7, 1905.

To Mr. John E. Spencer, *Chairman of Committee on Pumping Plant, Salem Sewerage Commission, Salem, Mass.*

Dear Sir: — The State Board of Health received from you on Aug. 3, 1905, a communication relative to certain plans of a pumping station and appurtenances for the sewerage system of the city of Salem, as follows: —

The undersigned, member of the Salem Sewerage Commission and Chairman of the committee on the Pumping Plant, is authorized and directed to confer with your Board regarding the approving of plans submitted to you by our engineer, Mr. Bowditch. These plans, in a general way, show what we intend putting in for a sewerage pumping plant to pump the sewage of Salem and Peabody.

Under the act authorizing the construction of this main trunk sewer and pumping plant and out-fall sewer for Salem and Peabody, the writer believes there is a clause which requires the State Board of Health to approve the plans, etc., as to size, capacity, etc. . . .

The undersigned, on behalf of the Sewerage Commission of the city of Salem, hereby requests that the State Board of Health shall pass upon the plans in accordance with the act authorizing this sewerage system.

The location of the proposed pumping station, the elevation of the sewer leading thereto, and other essential features of the plan for the collection and disposal of the sewage of the city of Salem, have already

been approved by the Board after due notice of the presentation of such plans to it for approval, and a hearing to all persons interested.

It does not appear to the Board that it is within its province to pass upon the design of the machinery or method of application of the power to be used, or other engineering details of the proposed pumping station and appurtenances.

The plans now presented show, in addition to the details of the proposed pumping station, the number and capacity of the pumps which it is proposed to use to pump the sewage, and a statement of the power to be employed. The pumping capacity which is to be provided, according to these plans, is about 25,000,000 gallons per day, which should be ample for all the requirements at this pumping station if the sewers now being built and the connections hereafter made therewith are constructed in a proper manner, and excessive leakage prevented.

It is important to screen the sewage before it passes to the pumps, and the screens indicated should serve the purpose. If a pumping plant of 25,000,000 gallons be provided, as now proposed, and ample power be made available for operating the pumps, the provision for removing the sewage brought by the main trunk sewer should be, in the opinion of the Board, adequate for all reasonable requirements of both Salem and Peabody.

Taunton.

May 10, 1905.

To the Sewer Commissioners of the City of Taunton.

Gentlemen: — The State Board of Health has considered your application for a further extension of the time for the completion of the plans of sewerage and sewage disposal for the city of Taunton approved by this Board on July 15, 1897, which, with a subsequent extension of the time in 1902, now provide for the disposal of all of the sewage of those sections of the city on the westerly side of the Taunton River, and shown upon a plan entitled, "Map of a section of the city of Taunton for proposed sewerage system, Luther Dean, City Engineer, 1897," upon land near the Assonet Neck Road in Berkley, on or before July 1, 1905, and has given a public hearing after notice to the parties in interest.

Having considered the evidence presented at the hearing and the information collected by its own investigations as to the condition of the river below the city, the Board has voted to extend the time for the completion of the sewerage and sewage-disposal system of the city of Taunton to July 1, 1906; and that, if at that time the city has shown due diligence in the construction of the main intercepting sewer necessary to convey the sewage from the present outlets into the Taunton River down to the point at which it is proposed to locate the pumping station, and in completing the removal of the sewage from Mill River, the Board will then consider the further extension of the time for the completion

of the sewerage and sewage-disposal works of the city, as provided in the plans approved by order of this Board on July 15, 1897, but not beyond July 1, 1910.

West Bridgewater (Howard Seminary).

June 12, 1905.

To the Trustees of the Howard Seminary, West Bridgewater, Mass.

Gentlemen: — In response to a petition from residents of the village of West Bridgewater, alleging the existence of a nuisance by reason of the present method of disposal of the sewage of the Howard Seminary, the State Board of Health has caused the locality to be examined.

It appears that the sewer from the seminary discharges first into a pond or pool on a small stream between Centre and River streets, at the outlet of which the flow of the stream, including the sewage, is again taken into the sewer and subsequently discharged into another pond southeast of River Street, near the Town River, and thence with other sewage into the Town River. Both of the ponds were very offensive when examined, and the discharge of sewage into the Town River is contrary to the provisions of existing laws on account of the location of sources of water supply near its banks below.

The Board would advise that a tight sewer be laid to convey the sewage of the seminary, and of such other places as now discharge sewage into the river or its tributaries in the village, to some suitable place where it may be purified. A filter bed constructed of coarse sand, 5 feet in depth, and having an area of about 3,000 square feet, would be sufficient for present requirements. If the drainage of the lands through which the present sewer passes is deemed necessary, the present sewer might be repaired and used for that purpose.

June 12, 1905.

To the Board of Health of the Town of West Bridgewater.

Gentlemen: — Complaints having been made to this Board by certain residents of the village of West Bridgewater relative to the objectionable conditions caused by the discharge of sewage from the Howard Seminary, the Board has caused the locality to be examined and finds that a serious nuisance now exists there by reason of the disposal of the sewage of the institution referred to and of other places.

This is a local nuisance, the existence of which your Board has ample power to prevent. A tight sewer should be laid to convey the sewage to some suitable place of disposal, where it should be purified, since the discharge of unpurified sewage into the Town River is contrary to existing laws. A filter bed constructed of coarse sand, 5 feet in depth, and having an area of about 3,000 square feet, would be sufficient for present requirements.

JUNE 12, 1905.

To ANNIE E. RIPLEY, GEORGE SHIPMAN, JOHN MARTIN and Others, *Petitioners relative to the Pollution of a Stream in West Bridgewater.*

In response to your petition of March 2, 1905, relative to the pollution of a stream in West Bridgewater by the sewage of the Howard Seminary, the State Board of Health has caused the locality to be examined and finds that the stream is very badly polluted by sewage at the present time, and has sent communications to the local board of health and to the trustees of the Howard Seminary, copies of which are enclosed herewith.

WESTON.

AUG. 3, 1905.

To Mr. ARTHUR J. RUSSELL, *8 Beacon Street, Boston, Mass.*

DEAR SIR: — The State Board of Health received from you on July 26 a communication outlining a plan for the construction of an open swimming pool, with a capacity of 42,000 gallons of water, to be located near School Street in Weston, the water of which you propose to purify by filtration according to the following plan: —

> We expect to empty this pool once each week, in five or six hours. As the land drains into a brook, emptying into the Stony Brook Reservoir, we shall need to make provision for a filter bed.
>
> We propose to supply a bed of sand 30′ 0″ x 30′ 0″ x 5′ 0″ deep, upon which the water will be delivered at four points.
>
> . . . .
>
> It is to be noted that shower baths are required before entering the pool.

The Board has considered the scheme presented and is of the opinion that, in order to obtain safe results in the purification of the water, the filter should have an area of at least 2,000 square feet, and the water should not be applied at a greater rate at any time than 3,000,000 gallons per acre in twenty-four hours. If these conditions are observed, with a filter composed of suitable sand 5 feet in depth, the pollution of the water of the stream into which the effluent flows can be prevented.

WORCESTER (INSANE HOSPITAL).

FEB. 2, 1905.

To the Trustees of the Worcester Insane Hospital, Mr. LAWRENCE B. WOODWARD, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on Jan. 31, 1905, an application for advice as to a proposed system of sewage disposal for the Worcester Insane Hospital, accompanied by plans of the proposed system and a report of your engineer relative to the proposed works.

The quantity of sewage discharged from the hospital at the present time is estimated to be about 85,000 gallons per day, which is now dis-

posed of by irrigation upon lands upon the slope of the hill east of the hospital, though a part of the sewage escapes at times into Lake Quinsigamond. The plans now submitted provide for collecting the sewage from the present sewers of the hospital in a settling tank and reservoir, and for purifying it by intermittent filtration upon filter beds to be constructed upon lands of the hospital, between 1,000 and 2,000 feet north of Belmont Street and 500 to 600 feet west of Lake Avenue, the effluent to flow into a small tributary of Lake Quinsigamond. The settling tank is to have a capacity of 6,000 gallons, according to the plans, and provision is made for the discharge at frequent intervals of the sludge accumulating in this tank upon filter beds prepared for the purpose.

The reservoir into which the sewage will pass after leaving the settling tank is to have a capacity of about 33,000 gallons, sufficient to flood one of the filter beds to a depth of between 4 and 5 inches. Provision is also made in the plans for the continued use of sewage in the future for the irrigation of crops.

The Board has considered the reports and plans submitted and has caused the locality to be examined by one of its engineers. The soil at the place where the filter beds are to be located is composed of coarse gravel of excellent quality for the purification of sewage by intermittent filtration, and the area which it is proposed to prepare is sufficient for the present requirements of the hospital.

If the works shall be constructed in accordance with the plans submitted, and if they then shall receive proper care, the Board is of the opinion that they will provide for the purification of the sewage of the hospital in a satisfactory manner. If the quantity of sewage discharged from the hospital shall increase, a larger area of filter beds will be required and could evidently be provided without special difficulty. It appears that the sewage has frequently been used for irrigation of crops, and has apparently been found of much advantage; and there is no reason why this use may not be continued in the future, provided that the application of the sewage to the crops be kept under such supervision as will prevent the escape of the sewage to the adjacent lands or waters, and the offensive odors which would result from allowing the sewage to stand in pools.

The Board would advise that works for the purification of the sewage of the institution be constructed as soon as practicable, in order to prevent the objectionable conditions which now exist caused by odors from standing pools of sewage and by the escape of unpurified sewage into Lake Quinsigamond.

Pollution of Ponds, Streams and Other Bodies of Water.

The following is the substance of the action of the Board during the past eleven months in reply to applications for advice relative to the pollution of ponds, streams and others bodies of water: —

Cohasset and Hull.

Dec. 7, 1905.

To Messrs. Albert A. Pope, Robert L. Scaife, H. W. Wadleigh, *and Other Residents of the Towns of Hull, Cohasset and Hingham.*

Gentlemen: — In response to your petition filed Oct. 13, 1905, calling attention to the filthy condition of Straits Pond, and requesting this Board to take action in the matter, the Board has caused a further examination to be made of the pond and its surroundings, and has considered the information collected in previous investigations relative to possible methods of improving the condition of this pond.

Straits Pond has caused much complaint from residents along its shores for many years. It has been examined from time to time by the Board since 1879, the most recent examination having been made in 1900 in response to a petition from residents in the neighborhood for advice as to a proposed plan of improvement. The results of this examination and the advice of the Board as to the plan then presented are contained in a communication to certain petitioners of Cohasset and Hull, a copy of which is enclosed herewith.

Examinations made in response to your petition do not show that there has been any material change in the conditions since that advice was given, though the evidence collected by the Board indicates that during the past summer the odors arising from this pond have been more offensive than usual. Judging from the information now available to the Board as to the character of this pond and of the organic growths by which it is affected, and the decay of which appears to be the chief cause of the objectionable odors complained of, there appears to be no other way of improving the condition of the pond than by removing the mud and organic matter from the bottom or covering it with sand or gravel and changing the water frequently.

The Board would advise that during the coming winter a survey be made of the pond to determine the depth of water and the depth and character of the mud and soil upon its bottom, and that plans for introducing an additional quantity of water be prepared. When the results of these investigations are available the Board will, if you so request, give you further advice as to improving the condition of this pond.

MILFORD.

OCT. 5, 1905.

To the *Board of Selectmen of the Town of Milford.*

GENTLEMEN: — The State Board of Health has received a petition (dated July 17, 1905) signed by 129 persons residing in that part of the town of Milford bordering on the Charles River, alleging the existence of a nuisance there, caused by the discharge of sewage from sewers of the town of Milford into the Charles River near the middle of the district, where the flow of the stream is so small that the stench becomes unbearable in the warmer portion of the year, and requesting this Board to take such action as will give relief from these objectionable conditions.

The Board has caused the river at the place indicated to be examined by its engineer and finds that sewage is discharged from the town sewers into the river in such quantity and under such conditions that the stream is foully polluted and is made offensive to those who live near it in this region during much of the year. These conditions are, in the opinion of the Board, prejudicial to the public health; and it will become the duty of the Board, under the circumstances, for the protection of the interests of persons and property affected, to report the matter to the Legislature for action, as required by chapter 75 of the Revised Laws, unless the town shall proceed to abate the nuisance.

If your board desires to make any communication to this Board upon the subject, the Board will be glad to receive it and will give it due consideration.

PITTSFIELD.

JUNE 1, 1905.

To the Hon. ALLEN H. BAGG, *Mayor of the City of Pittsfield, Mass.*

SIR: — The State Board of Health received on May 26, 1905, the following communication requesting advice relative to the improvement of the west branch of the Housatonic River at Pittsfield: —

I am directed by His Honor Mayor Allen H. Bagg to bring to the attention of your honorable Board the condition of the west branch of the Housatonic River in this city. It has been a dumping ground for refuse and filth and it is believed that it is a serious menace to the public health, a very large proportion of the deaths from contagious diseases in this city occurring in the western part of the city in the general neighborhood of this river.

It is respectfully requested that your honorable Board will take such steps as may be lawful and expedient looking toward an examination of the conditions to the end that we may be advised as to a remedy therefor.

A set of photographs showing the condition of parts of the west branch was recently left at the office of the chief engineer of the Board of Health.

In response to this communication the Board has caused the stream to be examined by its engineer and samples of its waters to be analyzed. The results of the examinations show that this stream is in a foul and offensive condition by reason of pollution by sewage and manufacturing waste, and the use of its banks as a dumping place for rubbish of all sorts, including garbage. The banks of the river where dumps are located are exceedingly unsightly and in some cases foul smelling; but the condition of the river itself is so bad that the offensive conditions along the banks are not so noticeable as they otherwise would be.

There is no question but that the dumping of rubbish into the river, as practised at present, should be prohibited. In most of the cities of the State the dumping and disposal of all refuse is regulated by the city under rules of the local board of health, and public dumps are provided and cared for by the city. The Board would recommend that in future the dumping of garbage and rubbish within the city limits of Pittsfield be regulated by the city under existing statutes, and that the enforcement of the regulations be placed in charge of one of the departments, which shall be responsible for the proper regulation and care of all places designated for the disposal of such waste, and that all dumping into streams be prevented.

A more important requirement for improving the sanitary condition of the west branch of the Housatonic River at Pittsfield is the removal of the sewage and manufacturing waste which now make the stream offensive to sight and smell throughout most of its length in the warmer portion of the year. The Board is informed that sewers are to be built this year which will divert all sewage from the West Housatonic Street drain, and that the drain is to be used in the future for the disposal of storm water only; and if this plan should be carried out the objectionable conditions caused by the drain will be removed. Regarding the disposal of the manufacturing wastes now discharged into the stream, the Board advised the city in 1903 to extend its sewers so as to receive these wastes and discharge them into the present sewerage system; and the Board would again advise that this is the only practicable plan of efficiently improving the sanitary condition of the west branch of the Housatonic River. These wastes can be disposed of satisfactorily in connection with the sewage of the city, and they should be collected and discharged into the sewers as soon as practicable.

A copy of the communication of the Board in 1903 relative to the disposal of the manufacturing wastes and the improvement of the condition of the west branch of the Housatonic River is enclosed.

Rhode Island.

Dec. 7, 1905.

To the State Board of Health, Providence, R. I., Dr. Gardner T. Swarts, *Secretary.*

Gentlemen: — The State Board of Health received from you on Dec. 5, 1905, a communication requesting the assistance of the Board in preventing the pollution of the water supply of East Providence, taken from the Ten Mile River, and of the water supply of Pawtucket, taken from Abbott Run, the water-sheds of both streams lying partly in the State of Massachusetts.

The water-shed of Ten Mile River contains many villages and is polluted by the sewage of the town of Attleborough and by sewage and manufacturing wastes in many other places. The Board considers that the pollution of the river to the present degree is very objectionable from a sanitary standpoint, and that the interests of the people of the valley require that further pollution of the stream should be prevented; but, on account of the large population within the water-shed of the stream, which amounts to about 20,000, or 460 persons per square mile near the State line, and the numerous villages and mills widely scattered throughout its water-shed, it is impracticable, in the opinion of the Board, to prevent the pollution of the stream by sewage and manufacturing wastes to such an extent as to render the water of the river below Attleborough suitable for drinking.

With regard to Abbott Run, it appears to the Board that the number of sources of pollution is not large, and that it will probably be practicable to protect this water-shed by providing suitable means for the disposal of sewage and household wastes at each point where pollution now occurs.

The laws of Massachusetts provide a way by which the pollution of a stream, pond, spring or water course used as a source of public water supply by manure, excrement, garbage, sewage or any other polluting matter can be prohibited by this Board; but the Board is not authorized to prohibit the use of any structure which was in existence on the eleventh day of June in the year 1897, unless provision shall be made by the owners of the water supply polluted therefrom for making such changes in the structure as may be deemed expedient. In the enforcement of laws for the prevention of pollution of water supplies in this State, it is the custom of the cities, towns and water companies interested to make all necessary changes in structures which are sources of pollution of their water supplies at their own expense.

If you will indicate the premises in Massachusetts from which Abbott Run is now being polluted, the Board will make the necessary examinations and co-operate with you in efforts to prevent the pollution of the stream therefrom.

SOMERVILLE (HINCKLEY RENDERING COMPANY).

NOV. 2, 1905.

To the Hinckley Rendering Company, Somerville, Mass.

GENTLEMEN: — In response to a petition of the Winter Hill Improvement Association and numerous persons living in the neighborhood of your works, alleging the existence of a nuisance by reason of the offensive odors arising therefrom, the State Board of Health has given a public hearing after notice to the parties interested and has examined the works and their surroundings. Much evidence was presented at this hearing to show that persons living near these works are affected by the offensive odors coming therefrom.

Upon the occasions when the buildings and their surroundings have been examined by the Board or its officers, the condition of the buildings as regards cleanliness has been satisfactory, but offensive odors were noticeable at a considerable distance from the works. Much foul drainage is discharged from the works through drains leading to the Mystic River in the rear of the buildings, where the drainage is discharged upon flats exposed at low tide; and a large area of flats in the neighborhood of the buildings is at present covered with a deposit of sludge, evidently derived from the wastes discharged from the works.

The Board has been thus far unable to determine to what extent the serious odors complained of are due to the emanations from the works themselves, and what portion of them is derived from the offensively polluted flats near the buildings; but, in any case, the Mystic River is not the proper place of disposal for foul drainage from these works, and the Board would recommend that they be discharged into the public sewers. If this shall be done, and the offensive deposits removed from the flats before the coming of warm weather again, it will then be practicable for the Board to determine what further measures, if any, may be required to protect the public health and comfort in this locality.

The Board would suggest that keeping the doors and windows closed so far as practicable, and providing a system of ventilation discharging into the main flue, would aid materially in preventing the escape of odors from these works.

WEYMOUTH.

DEC. 7, 1905.

TO MR. EDWARD J. PARKER, *Quincy, Mass.*

DEAR SIR: — In response to your request for an examination of Whitman's Pond and advice as to whether its condition is a menace to the public health, the Board has caused the pond and its surroundings to be examined and has collected information relative to cases of malarial sickness in this region.

The condition of the pond when examined was much the same as when the previous examination was made, in 1902. In most places the shores and bottom where exposed were clean and dry. In the westerly arm of the main pond, bordering the easterly side of Middle Street, a considerable quantity of organic matter was exposed by the drawing down of the pond. While the condition of this arm of the pond appears to be one requiring improvement, the information submitted to the Board does not show that there has been a marked increase in the number of cases of malarial disease in the town recently, as compared with previous years, nor does this evidence show that malaria has been more prevalent in the neighborhood of the pond than in other sections of the town.

The Board would recommend that a careful record be kept in future of cases of malarial disease occurring in the town, and if it is found that sickness is caused by the condition of the pond when the water is drawn down, the necessary improvement should be made. It is probable that the objectionable conditions in the part of the pond bordering Middle Street could be removed by thorough ditching.

Public Institutions.

The following is the substance of the action of the Board during the past eleven months in reply to applications for advice under the provisions of section 4 of chapter 75 of the Revised Laws: —

Massachusetts School and Home for Crippled and Deformed Children.

Dec. 7, 1905.

To the Board of Trustees of the Massachusetts School and Home for Crippled and Deformed Children, Mr. Francis Hurtubis, Jr., *Secretary and Treasurer.*

Gentlemen: — The State Board of Health received from you on November 17 the following application for advice as to two possible locations for the proposed Home for Crippled and Deformed Children: —

I am instructed by the Board of Trustees of the Massachusetts School and Home for Crippled and Deformed Children respectfully to request your Board to direct its engineer to examine the Gammell farm, so called, situated in the town of Lexington, and the Capen property, situated in the town of Canton, and to furnish this Board with a written report upon the advisability of selecting either of these properties as a site for the School and Home for Crippled and Deformed Children, and more particularly upon the following points: —

First. — What would be the best method of disposing of the sewage of such an institution as the Board contemplates building?

Second. — What would be the difficulties or obstacles which the Board would have to meet in constructing the several systems discussed?

Third. — What would be the approximate cost of constructing, considering all physical and atmospheric conditions, the different systems?

Fourth. — What system of sewerage would the Board of Health advise?

Fifth. — Are the water supplies in both of these towns sufficient and satisfactory?

In response to this application the Board has caused the two locations indicated to be examined, and finds that either one would be suitable for the proposed institution, so far as the climatic or other conditions possibly affecting health are concerned.

At Lexington the best practicable plan of disposing of the sewage is to discharge it into the metropolitan sewerage system, the main sewer of which is already laid to the boundary line between Lexington and Arlington, not far from the site of the proposed institution. To dispose of the sewage in this way it would be necessary for the institution to construct a sewer, and probably also to pay an annual assessment to the town or to the Metropolitan District.

At Canton there is no public sewerage system, but the sewage of the institution could be disposed of satisfactorily at much less expense than at Lexington at any convenient place upon the grounds of the institution, the soil being very coarse and porous and well adapted to the purification of sewage by filtration.

It is impracticable for the Board to give you a definite estimate of the cost of sewage disposal in either case, but the cost of the disposal works at Canton would without doubt be considerably less than at Lexington.

At Lexington the water supply would be obtained from the metropolitan system, and at Canton from the Canton water works. Both supplies are of good quality for all domestic purposes.

Rutland (Industrial Camp for Prisoners).

July 6, 1905.

To the Prison Commissioners, Mr. Fred G. Pettigrove, *Chairman.*

Gentlemen: — In response to your request of May 29, the Board has considered the proposed location of a hospital prison for consumptives at the Temporary Industrial Camp for Prisoners at Rutland, and has caused the locality to be examined by one of its engineers.

It appears that two locations for the institution are under consideration by your Board; one on the easterly side of the highway, between the highway and the Ware River, on a knoll much above the surrounding land, but near the present camp; and the other on the westerly side of the highway, on a wooded hill. Of the two locations, the one on the easterly side of the highway is the more desirable.

The present water supply of the institution is limited, and it is now contemplated to take water from the ground near the river a short

distance below the camp and about equally distant from each of the locations for the hospital now being considered. Whether the source mentioned, or some other in the neighborhood, shall finally be selected for the water supply of the institution, it would not be difficult to furnish water to a hospital at either location; and the sewage of a hospital in either location could be disposed of in connection with the sewage of the other buildings of the temporary camp under the plan already approved, — enlarging the filter beds if necessary, which can be done without special difficulty.

Examination of Public Water Supplies.

Examination of Public Water Supplies.

Nearly all of the sources of public water supply in Massachusetts have been examined during the year by the engineer of the Board or his assistants, and chemical analyses of their waters have been made as usual at regular intervals.

The following report contains such information as is deemed to be of special interest concerning the various sources of supply and descriptions of the changes and additions made since 1898, when a description of all the various sources was published. In cases where the source of supply remains the same as in that year, and no material change has taken place in its condition or surroundings, it will not be referred to in this report, and reference is made to the report of 1898 for information regarding the works.

A summary of the results of the chemical analyses of the waters of the various sources will be found in two tables appended hereto, the first containing the averages of chemical analyses of the various surface-water supplies examined, and the second the ground-water supplies.

Amesbury. — The sources of supply are two systems of wells, one located near Market Street, supplying the high-service system, and the other near Main Street, supplying the low-service system.

At Market Street there is a large well 18 feet in diameter and 45 feet deep, at the bottom of which a 16-inch well has been driven to a further depth of 200 feet. There are also 3 8-inch wells driven to a depth of about 200 feet. The water obtained from these wells is very hard and the quantity is limited.

The Main Street system consists of two open basins, one of which is 100 feet long, 50 feet wide and 15 feet deep, with 12 3-inch wells driven to a further depth of 100 feet. The second basin is 60 feet long, 40 feet wide and 11 feet deep, and contains 12 2-inch wells driven to a further depth of 20 feet. There are also 6 other wells near the basins, driven to depths of from 85 feet to 125 feet. The Main Street wells are in the vicinity of a large population, drainage from which evidently affects the water of this source. There has been a rapid deterioration in the quality of the water of the Main Street wells within the past five years, which is shown by the table of yearly averages of chemical analyses, on page 167.

Amherst. — The source of water supply is Amethyst Brook in Pelham, water being taken from a small intake reservoir. The water-shed of the brook above the intake reservoir has an area of 6.3 square miles and contains a scattered population. Upon the southerly branch of the brook about a half a mile above the intake reservoir there is a storage reservoir having an area of 4½ acres and a storage capacity of about 13,000,000 gallons. This reservoir was constructed originally without removing any of the loam or subsoil from the area flowed, and the water of the reservoir has frequently been objectionable on account of the presence of large numbers of organisms. During the year 1904 the water was drawn from the reservoir, and the mud and organic matter were either removed from the bottom or covered with sand.

Ashfield. — A system of water works was constructed for the supply of this town in 1904 by the Ashfield Water Company. The source of supply is Bear Swamp Brook, in the northwesterly part of the town. A small intake reservoir has been constructed upon this brook at the point where it crosses a highway about a quarter of a mile above the road leading from Ashfield to Hawley. This reservoir has a tributary drainage area of about .45 of a square mile, which is uninhabited. From the intake reservoir the water flows to a lower reservoir nearer the village, which has a capacity of 250,000 gallons and is used as a distributing reservoir.

Attleborough. — During the year 1904 an additional well was constructed near Orr's Pond and about 250 feet from the old well. The original well did not furnish enough water to operate the pumps at their full capacity and at times of unusual draft it has been necessary to pump water from Orr's Pond. The new well is 40 feet in diameter, 25 feet deep, and is connected with the old well by a gallery so constructed as to act as a filtering conduit.

Billerica. — The source of supply is a system of tubular wells in the meadows on the west side of Concord River. The wells — 35 in number — are driven to depths of from 14.5 feet to 41 feet, the average depth being 25.4 feet. Before the works were constructed test wells were driven and water was drawn continuously from 7 of the wells by means of a steam pump for a period of about 10 days. The results of the test showed that the water was of unsatisfactory quality, owing to its disagreeable odor and the quantity of iron present. Further tests were made in other parts of the meadow, and a location was finally found where the water after continuous pumping for several days remained of satisfactory quality; but in constructing the works the wells were driven in 5 distinct groups so arranged that any group can be disconnected if the water in that place deteriorates. The works were completed in

1898, and the water has been of satisfactory quality, although the quantity of iron present in the water is rapidly increasing. A table of yearly averages of analyses of samples of water from these wells is given on page 167.

Bridgewater and East Bridgewater. — The works supplying these towns were built by the Bridgewaters Water Company. The original sources of supply were 2 large wells, sunk through clay and hardpan to the level of the water of the river at its normal stage. Subsequently a third large well was sunk a few feet further east to a depth of 27 feet, its bottom being 14 feet below the level of the river. A tubular well in the bottom of this well extends to a further depth of 86 feet. These 3 wells are from 135 feet to 200 feet from Town River.

A further supply becoming necessary, 14 driven wells were added, each of which is 6 inches in diameter, their depths ranging from 99 to 202 feet. Seven of the wells are located between the large wells and the river, and the others about 1,000 feet down stream in a meadow which is sometimes flooded by the river. An additional supply is also obtained at times from an artificial pond formed by damming a very small stream close to the river at a point about 1,000 feet up stream from the pumping station. The region about the wells is very sparsely populated, the nearest buildings being about 600 feet distant.

Early in the spring of 1905 the Bridgewaters Water Company made an application for the advice of the Board as to increasing the supply of water by filtering the water of Town River, near which the wells are situated. Town River opposite the wells drains an area of about 56.2 square miles, which includes several villages, and the stream receives much pollution from sewage and manufacturing wastes. The river drains large areas of swamp lands and the quality of the water is naturally very poor. The reply of the Board to this application will be found on page 39.

Brockton. — A public water supply was introduced by the city in the year 1880, and the source of supply from that time until 1904 was a storage reservoir on Salisbury Brook, the water of which has always been objectionable on account of the high color and the presence of large numbers of microscopic organisms, which have frequently caused it to have a disagreeable taste and odor.

On Oct. 12, 1904, works for taking water from Silver Lake in the towns of Kingston, Plympton and Pembroke were completed, and since that date all the water used by the city has been supplied from Silver Lake. The town of Whitman has also been supplied with Silver Lake water since Jan. 1, 1905, under a contract with the city of Brockton.

Silver Lake has an area of 644.5 acres and a drainage area of 4.4 square miles, including the area of the lake. The water-shed contains a few

farm buildings, and, at the request of the Brockton Water Board, rules and regulations for the protection of this source of supply were adopted by the State Board of Health in 1905 under the provisions of the Public Statutes.

The water of Silver Lake is naturally of excellent quality but is affected occasionally, in common with that of many other similar sources, by the presence of organisms which impart to the water a disagreeable taste and odor. The water was affected in this way for a short time in the early summer of 1905, the objectionable taste and odor having been caused by the presence of considerable numbers of the organism *Anabæna*.

Brookline. — The original source of supply was a filter-gallery located on the right bank of Charles River at West Roxbury. The total length of the gallery is 1,142 feet, its width from 4 feet to 6 feet, and the bottom of the gallery is about 6 feet below the level of low water in the river. Water is also taken from a system of 178 tubular wells driven on both sides of the river to depths of from 35 to 95 feet. The water contains an increasing quantity of organic matter, derived probably from the imperfectly purified river water which finds its way into the wells. Yearly averages of chemical analyses are given on page 168.

Cohasset. — The works are owned by the Cohasset Water Company. At the present time the sources of supply are two systems of driven wells about half a mile apart on the southwest side of the main village, and a filter-gallery on the northerly shore of Lily Pond. The water of one of the systems of driven wells is affected by the presence of excessive quantities of iron, and also to some extent by the population upon the area drained by the wells. The water of the filter-gallery contains a very large quantity of organic matter and much iron, due to the imperfect filtration of water from Lily Pond into the filter-gallery. An open distributing reservoir is still used in connection with these works, and, as usual in the case of ground waters exposed to light in such reservoirs, the water deteriorates and is affected at times by the presence of large numbers of microscopic organisms.

Dalton (Dalton Fire District). — The water supply of the Dalton Fire District is taken from Egypt Brook, on which there is a small storage reservoir having a capacity of about 12,000,000 gallons. From this reservoir the water flows to a smaller reservoir constructed near the brook a short distance below the storage reservoir. The total water-shed of these sources is about 1.5 square miles. The supply was increased in 1905 by diverting into the lower reservoir near Egypt Brook the water of Anthony Brook, the water-shed of which is adjacent to that of Egypt Brook on the east.

Deerfield (South Deerfield Water Supply District). — Works for the

supply of the South Deerfield Water Supply District were constructed by the district in 1904. The source of supply is Roaring Brook in the town of Whately, on which a small intake reservoir has been constructed. Water is supplied by gravity. The brook has a water-shed of 4.8 square miles, which contains a small scattered population.

Fairhaven. — The town is supplied with water by the Fairhaven Water Company and the source of supply is a group of tubular wells in the valley of Nasketucket River. The wells are so situated that at times they receive surface water without thorough purification. The increasing amount of surface water entering the wells is indicated in the table of yearly averages of chemical analyses on page 168.

Framingham. — The town of Framingham is supplied with water by the Framingham Water Company. The supply is derived chiefly from a filter-gallery on the shore of Farm Pond. The filter-gallery is circular in section, 5 feet in diameter, 550 feet long, and the bottom is 8 feet below the ordinary water level in Farm Pond. In some places the gallery extends beneath the bottom of the pond, but the top of the gallery is said to be impervious, so that the water passes through at least 5 feet of sand before entering the gallery. The quantity of water which can be obtained from the filter-gallery is insufficient at times for the supply of the town, and a small quantity is drawn at such times from the Sudbury River Aqueduct of the Metropolitan Water District. The quality of the water of the filter-gallery has deteriorated steadily since the first analyses were made in 1887. This deterioration is shown in the table of chemical analyses on page 169.

Franklin. — The works are owned by the Franklin Water Company and were built in the year 1884. Water is drawn from two wells beside Mine Brook on the easterly side of the village, and from Beaver Pond. The water of the wells is unfavorably affected by the sewage from the large population in the village, which is discharged upon or into the ground on land sloping toward the wells. Mine Brook is grossly polluted by manufacturing wastes and sewage from several manufacturing establishments located upon the stream above the wells. The course of Mine Brook lies between the wells and Beaver Pond, being separated from the latter by a low ridge submerged at times of high water in the brook. Under these circumstances the polluted water of Mine Brook could flow directly into the pond, and on June 6, 1901, the State Board of Health called attention to the danger to the health of those using water from the Franklin water works under these conditions. No improvement has been effected, however. On the contrary, it appears that the dam on Mine Brook has been raised so that Mine Brook can flow at all times into Beaver Pond.

The Board has again called the attention of the Franklin Water

Company and the Franklin authorities to the fact that the source of water supply of the town is subject to constant pollution by sewage under the present conditions and is liable to injure the health of those who use the water for drinking.

Great Barrington (*Great Barrington Fire District*). — The works are owned by the Great Barrington Fire District. The water supply is taken from two sources: one, Green River, — a tributary of Housatonic River, which drains an area of about 52 square miles above the point at which the water is taken for the supply of the village, — and the other, East Mountain Reservoir, so called, having a capacity of about 1,000,000 gallons, with a tributary water-shed of about .25 of a square mile. The water-shed of East Mountain Reservoir is uninhabited, but the supply from this source is limited and probably does not exceed an average of 100,000 gallons per day during the drier half of an ordinary year. It is estimated by the authorities of the district that the consumption of water is from 400,000 to 500,000 gallons per day, so that the bulk of the supply is taken from Green River.

Of the 52 square miles of water-shed draining into Green River above the point at which water is taken, 29 square miles are within the limits of the State of Massachusetts and 23 square miles in the State of New York. Within the portion of the drainage area in New York there are many dwelling houses and outbuildings, including three small villages located upon the banks of the stream and its tributaries. There is also a population of over 900 living within the water-shed of Green River within Massachusetts. Under these conditions it is impracticable to protect this source from pollution, and the authorities of the district have been repeatedly so advised.

By the provisions of chapter 245 of the Acts of the year 1902, the Great Barrington Fire District is authorized to take water from various streams in its neighborhood, subject to the approval of the State Board of Health. For several years the matter of a new supply has been under consideration by the district, and during the past year plans for taking water from Goodale Brook and adjacent streams were approved by the State Board of Health. Copies of the communications relative thereto will be found on pages 46, 48 and 49.

The proposed sources of supply would furnish excellent water at a reasonable cost to the district; but the plans have not been carried out, and the district continues to use the water of Green River, notwithstanding its exposure to pollution.

Greenfield (*Greenfield Fire District*). — The works are owned by the district and water is obtained from Glen Brook in Leyden, upon which there is a storage reservoir having an area of 5½ acres and a capacity

of 18,000,000 gallons. Auxiliary works were installed in 1895 for pumping water from Green River to supplement the supply from Glen Brook. In 1905 a second storage reservoir, having an area of 7½ acres and a storage capacity of 45,000,000 gallons, was constructed on Glen Brook just above the existing reservoir there.

The drainage area of Glen Brook at the dam of the lower reservoir is about 5.36 square miles. It contains a considerable population, and, in response to a request from the town authorities, the State Board of Health has adopted rules and regulations for protecting the purity of this source. Some of the buildings on this water-shed are a considerable menace to the purity of the water supply.

Hadley (*Hadley Water Supply District.*) — Works for the supply of the Hadley Water Supply District were built by the district in 1905. The source of supply is Hart's Brook in Hadley, on which a small storage reservoir has been constructed. The reservoir has a storage capacity of about 2,000,000 gallons and a water-shed of a quarter of a square mile, which is uninhabited. Water is supplied to the district by gravity.

Hingham and Hull. — The towns of Hingham and Hull have been supplied for many years by the Hingham Water Company with water drawn from Accord and Fulling Mill ponds, water from the former being supplied to Hingham by gravity, while the town of Hull has been supplied chiefly with water pumped from Fulling Mill Pond. The water of Fulling Mill Pond is objectionable in quality on account of the large quantity of organic matter usually present, which gives the water a disagreeable taste and odor. In 1903 the use of the pond was abandoned and works were constructed for taking water from the ground near the pond and for filtering the water of the brook which is its main feeder.

The works consist of a well 40 feet in diameter and 20 feet deep, constructed near the easterly side of the pond, and two filter beds constructed near the brook and connected with the collecting well by a pipe line several hundred feet in length. The two filter beds are each 200 feet long and 15 feet wide and contain above the underdrains a depth of about 15 inches of sand. The water of the brook flows by gravity upon these filter beds. The pipe leading from the filter beds to the well for a portion of the distance is laid with open joints, in order to collect ground water from the soil between the filters and the well. The quality of the water obtained in this way is very much better than that furnished by Fulling Mill Pond.

The Hingham Water Company has been advised to provide for the filtration of the water of Accord Pond also, which often becomes very

objectionable for drinking on account of the presence of microscopic organisms, chiefly *Uroglena;* but nothing has yet been done to provide for the purification of the water of that source.

Holden. — Works for supplying this town with water were constructed by the town in 1905. The source of supply is Muschopauge Pond in Rutland, which is the source of supply of the latter town also. Water for the supply of Holden is taken from a point near the outlet of the pond and is supplied by gravity. The pond has an area of 58 acres and a water-shed of .6 of a square mile, which contains a few houses, none of which are situated near the shore of the pond.

Hyde Park. — The original source of supply of the Hyde Park Water Company was a system of tubular wells near the south bank of Neponset River. In 1900 a system of tubular wells was constructed on the southerly bank of Mother Brook in Dedham, near the boundary line between the towns of Dedham and Hyde Park.

The works near Neponset River consist of wells driven to depths of from 25 feet to 40 feet. Some of the wells are located close to the river, while others are situated at a considerable distance from it, and the character of the water from the different wells varies greatly. Some of the wells formerly used have been disconnected on account of the poor quality of the water drawn from them.

The quality of the water drawn from the wells deteriorated rapidly up to the year 1901, when the draft from them was decreased by the introduction of water from the new wells near Mother Brook. This was followed by a decided improvement in the character of the water for a time, but the water very soon began again to deteriorate, and at the present time it is of poorer quality than before the new supply was introduced.

The works at Mother Brook consist of 21 tubular wells, driven to depths of about 30 feet. These wells are driven in a meadow bordering Mother Brook, and there is a large and increasing population upon the area which is naturally tributary to them. The water of these wells also has deteriorated somewhat since the water was first drawn from them.

The yearly averages of analyses of samples of water from both systems of wells may be found on pages 169 and 170; and a diagram is also presented, showing the changes in the character of the water of the old wells, together with the quantity of water drawn from them.

Ipswich. — The water supply of Ipswich is drawn from a storage reservoir on Dow's Brook, which has an area of 18.2 acres and a storage capacity of 55,000,000 gallons. The water of the reservoir has often caused complaint on account of a disagreeable taste and odor, and ex-

periments have been made by the town, with the co-operation of the Board, upon filtering the water of this source in order to improve its quality. The attention of the authorities has also been called repeatedly to the danger to the health of the town which now exists by reason of the pollution of the reservoir by foul drainage from the dwelling houses and other buildings situated on its northwesterly side; and in a communication to the water commissioners of the town, on Feb. 4, 1904, the Board advised the construction of filters and the filtration of all of the water supplied to the town. This advice has not as yet been followed.

Lawrence. — The works are owned by the city and water was first introduced in the year 1875, the source being Merrimack River, from which water was taken directly. In the year 1893 a filter was built near the pumping station, under the advice of the State Board of Health, and since that time all of the water supplied to the city has been filtered. The filter was designed to be of sufficient capacity for the requirements of the city at the time it was built; but the original design, which included a cover or roof to protect the filter in winter, was not carried out, and the operation of the filter has been greatly interfered with in cold weather.

In the winter of 1901 the consumption of water in the city was for a period of many days greater than the capacity of the filter, and the water stored in the distributing reservoir, which has a capacity of 40,000,000 gallons, became nearly exhausted. Early in the spring of 1902 the Board urged the city to cover the filter and to provide as soon as practicable an additional filtering area; but the only action taken by the city was to divide the filter into three parts by means of walls, by which a very little improvement was made in its operation.

In the winter of 1902–03 — an exceptionally mild one — enough water was obtained for the supply of the city; but in the winter of 1903–04 and again in the winter of 1904–05 the water in the distributing reservoir became nearly exhausted, so that if a large fire or other emergency had arisen it would have been necessary to introduce the sewage-polluted water of Merrimack River directly into the city's mains without filtration.

The matter was brought to the attention of the Legislature of 1905 and an act passed directing the city to provide an adequate supply of pure water. During the past summer investigations have been made with a view to securing an additional supply from tubular wells.

About three-quarters of the service pipes of the city of Lawrence are of lead, but investigations have shown that the water of the present source, while taking up a considerable quantity of lead from the pipes,

does not probably take up enough lead to cause serious injury to health; but it is essential, under the circumstances, in selecting an additional supply, to secure one which will not be likely to take up greater quantities of lead when passing through lead service pipes than the present supply. All of the well-water sources investigated were found to contain carbonic acid, — the active agent in dissolving lead, — in much greater amounts than were found to be present in the water of the present supply. Under the circumstances, the Board was unable to approve the selection of these sources.

Copies of communications from the Board to the authorities of the city of Lawrence during the year with reference to proposed additional supplies will be found on pages 53 to 60 of this report.

No final action has yet been taken by the city to provide an adequate supply of good water.

Lowell. — Works for the supply of the city of Lowell were constructed in 1872, the source of supply being Merrimack River, above the city. In 1893 a system of tubular wells was constructed in the valley of River Meadow Brook, and subsequently a second system of wells was driven at another point in the valley of this brook. Finally, a system was constructed on the north bank of Merrimack River, the last being known as the "Boulevard wells," and the use of water drawn directly from Merrimack River was discontinued in 1898.

In 1899 it was discovered that the water of the tubular wells in the valley of River Meadow Brook took up lead from lead service pipes in such large quantities as to cause many cases of lead poisoning; and in accordance with the advice of the State Board of Health the city abandoned the use of these wells, and since 1900 the entire supply has been taken from the Boulevard wells near Merrimack River, the water of which attacks lead less freely. In 1901 the Boulevard plant was enlarged by the addition of a large number of wells.

The water of the Boulevard wells in the beginning was of fair quality, but with the increase in the quantity of water drawn from the ground the water has deteriorated. In 1901, after the works were enlarged by the construction of additional wells, the quality of the water as a whole improved, but since that time it has again steadily deteriorated.

The yearly averages of analyses of water from the Boulevard wells are given on page 170.

Lynn. — During the past year the new dam at Walden Pond has been completed. By the construction of this dam the level of the water in Walden Pond can be raised about 20 feet above the former high-water level, and Glen Lewis Pond, which was just above Walden Pond, will be submerged. The area of the newly formed Walden Reservoir will be

about 240 acres, its average depth 22 feet, and its storage capacity about 1,750,000,000 gallons. The area of the water-shed is small, compared with the capacity of the reservoir, but it is proposed to deliver into it some of the surplus water of Saugus River. The water of the latter source flows into Hawkes Pond, and water from Hawkes Pond will flow by gravity into Walden Reservoir when the water in the latter is low; but it will be necessary to pump the greater portion of the water from Hawkes Pond into Walden Pond, and a pumping station has been constructed for this purpose. Further reference to the character of the water supplied to the city of Lynn from Saugus River and the other sources will be found on page 3.

Marblehead. — The sources of supply are two wells in the valley of Forest River, in Salem. The well from which water is taken to the pumps is 30 feet in diameter and 30 feet in depth. The second well is 25 feet in diameter and 34 feet deep, situated in the bed of a pond which has been drained, and water from this well flows by gravity to the first well. The water from both of the wells has always contained an excessive quantity of iron, and the water supplied to the town has been unfit for many domestic purposes. The quantity of iron is increasing rapidly with the increased quantity of water drawn from the wells. The deterioration in the quality of the water is shown in the table of analyses on page 170.

Merrimac. — Works for the supply of the town of Merrimac were constructed by the town in 1904. The source of supply is a system of tubular wells in a sandy plain at the edge of the swamp which borders Lake Attitash, or Kimball's Pond. The system consists of 18 tubular wells, driven to depths of about 35 feet. Water is pumped from the wells to a covered standpipe.

Methuen. — The source of supply is a system of tubular wells in the valleys of Spicket River and of Harris Brook, a tributary of Spicket River. The collecting system consists of 146 wells, driven to depths of from 25 feet to 50 feet. Many of the wells are situated close to the edge of the stream, and at times of high water much of the land in the vicinity of the wells is overflowed. The water drawn from the wells has deteriorated rapidly, and at present there is sufficient iron to make the water objectionable for some domestic purposes. The yearly averages of analyses of samples of water from this source are given on page 171.

Middleborough. — The source of supply is a well 26 feet in diameter and 22 feet deep, about 100 feet from the east bank of Nemasket River. The water first drawn from the well was colorless and otherwise of satisfactory quality, but its quality has steadily deteriorated, until the water is objectionable for many domestic purposes on account

of the large quantity of iron which it contains. The yearly averages of analyses of samples of water from this source are given on page 171.

Millbury. — The works are owned by the Millbury Water Company and water was introduced in 1895. The source of supply is a well 20 feet in diameter and 20 feet deep, from which water is pumped to the town and to a distributing reservoir holding about 1,500,000 gallons.

Early in September, the water in the reservoir having fallen to a low level, about 300,000 gallons of water were pumped from Singletary Brook, a short distance below Singletary Pond. It is evident from this experience that the capacity of the well from which the supply has hitherto been drawn is not sufficient for the present requirements of the town.

Natick. — The water supply of the town of Natick, from 1873, when water was first introduced, until 1903, was drawn from Dug Pond. The water of this pond was naturally of poor quality and the pond was also greatly polluted by the large population within its water-shed. In 1903 works were constructed for taking water from the ground on the easterly shore of Lake Cochituate and the use of the pond was abandoned. The new source of supply is a well 31 feet in diameter and 21 feet in depth, located between the Worcester turnpike and the southerly arm of the lake. In connection with the new works a new covered distributing reservoir has been constructed, so that the water is delivered to consumers without exposure to light.

Newburyport. — The water supply of Newburyport is drawn in part from a group of large covered wells and in part from an open basin which receives the flow of several springs, including the Jackman Spring, so called. The works are located near the southerly bank of Merrimack River, above the city and about half a mile above the chain bridge leading from Newburyport to Amesbury. During the past year 4 deep tubular wells have been bored, chiefly in rock, in the valley of the main feeder of the open basin, and water from these wells is pumped into the basin. The wells are from 100 to 175 feet in depth.

A copy of the advice of the Board to the authorities of the city of Newburyport, relative to the cause of a disagreeable taste and odor in the water supplied to the city, will be found on page 65.

Newton. — The source of supply is a covered filter-gallery or conduit, 7,000 feet in length, constructed of wood and vitrified clay pipe, with which many tubular wells are connected, extending along the valley of Charles River.

The collecting system receives a large quantity of water from the ground above the wells, but at times a considerable quantity is evidently obtained by filtration from the river. The quality of the water has deteriorated slowly since the first analyses were made, eighteen years ago,

showing the increasing population upon the water-shed tributary to the wells and the increasing proportion of water obtained from the river without thorough purification.

Analyses of samples of water collected from these works may be found on page 171.

Northampton. — The water supply of Northampton is now obtained from West Brook in Whately and from the Mountain Street Reservoir on Beaver Brook in Williamsburg, Roberts Meadow Brook — the former source of supply — being reserved for use in case of emergency. An intake reservoir has been constructed on West Brook just below its junction with Avery Brook in West Whately. The brook at this point has a water-shed of 7.2 square miles, which contains a scattered population. Many of the houses which were situated near the brooks have been purchased and removed by the city. From the intake reservoir on West Brook the water is conveyed through a cast-iron pipe which discharges into the head waters of Beaver Brook, through which it flows to the Mountain Street Reservoir.

The Mountain Street Reservoir has an area of 37.5 acres, a storage capacity of 142,000,000 gallons, and was prepared for the storage of water by the removal of all loam and organic matter from its bottom. The reservoir has a direct water-shed of .7 of a square mile.

North Attleborough. — During the year 1905 the water supply has been increased by the construction of a well near Ten Mile River in Plainville, about a mile north of the old well. The new well is 30 feet in diameter and about 25 feet deep, and water from it flows by gravity to the well near the pumping station.

Norwood. — The works are owned by the town and were built in 1885. The source of supply is Buckmaster Pond in Westwood, which has an area of 29.5 acres and a capacity of about 123,000,000 gallons. The water-shed of about 250 acres contains a small population.

The quantity of water used by the town probably exceeds the capacity of the source in a series of very dry years, and the pond is in every year drawn to a very low level. At the end of November in the present year it had been drawn down 11 feet.

Late in 1904 the Board was informed of a case of lead poisoning believed to be due to drinking the water of the Norwood water works drawn through a lead service pipe. An investigation was immediately made and numerous samples of water were collected from various service pipes in Norwood and the quantity of lead determined. The results of the analyses of these samples showed the presence of quantities of lead much greater than those which have been known to cause lead poisoning, and the town authorities were advised of the danger to health

involved in the continued use of this water when drawn through lead service pipes.

Surface waters have not, as a rule, been found to take up enough lead, when drawn through lead service pipes, to cause noticeable injury to health. Investigations many years ago showed that waters containing carbonic acid take up lead from lead service pipes; and the greater the quantity of carbonic acid present in the water, the larger the quantity of lead dissolved in the passage of the water through the pipes. The quantity of carbonic acid present in surface waters is, however, usually small, and for this reason the conditions at Norwood are exceptional.

It should be noted here that examinations of the water supply of Norwood in 1898 failed to show the presence of considerable quantities of lead. It is possible that the change in the character of the water is due to the drawing of the pond in more recent years to a much lower level than formerly and to the fact that, under these conditions, much of the water enters the pond after percolation through the ground.

A copy of the advice of the Board will be found on page 68.

Peabody. — The present sources of supply are Brown's Pond in Peabody and Spring Pond in Peabody, Lynn and Salem. Spring Pond has an area of 63.6 acres, a drainage area of 315 acres, including the pond, and a total storage capacity of about 470,000,000 gallons. Brown's Pond has an area of 27.7 acres, a water-shed of 408 acres and a storage capacity of about 123,000,000 gallons. From Spring Pond the water flows into a storage reservoir formed by a dam on the stream below the pond, from which the water is pumped for the supply of the town. This reservoir has an area of 16.3 acres, a direct water-shed of 203 acres, including the reservoir, and a storage capacity of 30,000,000 gallons. The total water-shed tributary to this source of supply, including the water-shed of the ponds, is 926 acres.

The quantity of water pumped for the supply of the town in 1904 was 1,666,000 gallons per day, in addition to which a quantity, estimated to be about 200,000 gallons per day, was supplied to manufacturers in Salem. This total quantity used from the ponds (1,866,000 gallons per day) in 1904 is probably more than 700,000 gallons per day in excess of the capacity of these sources in a dry period.

Early in the year the authorities of the town submitted to the Board for its advice a plan for enlarging the water supply of Peabody by taking water from Suntaug Lake, the right to the use of which the town had acquired many years ago, through a pipe to be laid from Suntaug Lake to Spring Pond and the pumping station. It was proposed to take water also at some future time from Fish and Boston brooks, in the towns of Middleton, North Andover and Boxford.

An examination of the plan showed that, with the addition of Suntaug Lake, the total capacity of the combined works would not equal the quantity of water used from the sources of supply in 1904, and that it would consequently very soon be necessary to extend the works to take the waters of Fish and Boston brooks; but the quality of the waters of both of these sources was found to be objectionable on account of their high color and the large quantity of organic matter taken up by these waters in passing through the extensive swamps on their water-sheds; and the Board deemed it advisable, under the circumstances, that an investigation be made to determine whether it was not practicable to obtain water from some source likely to furnish a sufficient supply of water of satisfactory quality. Subsequently it appeared that, owing to the small rainfall during the winter of 1904–05, Spring and Brown's ponds had failed to fill, and that an auxiliary supply was required for immediate use during the present year. The Board then advised that an effort be made to secure a temporary additional supply from neighboring municipalities, but that, if this was not found practicable, Suntaug Lake was the most available temporary source of supply to meet the present emergency, and advised that if works should be constructed for taking water from this source they be made of a temporary character. Copies of both communications will be found on pages 70–76.

Scituate. — The town of Scituate is supplied with water by the Scituate Water Company from works completed in 1901. The source of supply is a system of 30 tubular wells in the valley of a small brook near Scituate Harbor. Water from the wells is pumped to a covered standpipe.

Shirley (*Shirley Village Water District*). — Works for the supply of the Shirley Village Water District were constructed by the district in 1903, water being obtained from a filter-gallery near Catacoonamug Brook, below the thickly settled portion of the town. The gallery is 50 feet long, 8 feet wide and 10 feet deep, the lower portion of the walls being constructed of stone, laid without cement. Water is pumped from the gallery to a covered standpipe.

Spencer. — The water supply of the town of Spencer is drawn from Shaw Pond, which has an area of about 70 acres and a drainage area of .57 of a square mile, including the pond.

The quantity of water drawn from the pond has been in excess of its capacity for several years, and early in 1905 it became evident that water would have to be obtained from some auxiliary source. Upon petition from the water board, the State Board of Health approved the use of Whittemore Pond as a temporary source of water supply under the provisions of chapter 25, section 35, of the Revised Laws, and this

source has been used during the latter part of the year. Whittemore Pond, also known as Moose Pond, has an area of about 50 acres and a water-shed of about .8 of a square mile.

A copy of the advice of the Board to the town of Spencer, approving the use of Whittemore, or Moose, Pond as a temporary source of water supply, will be found on page 85.

Springfield. — The principal source of supply is Ludlow Reservoir in the town of Ludlow, which has an area of about 430 acres and a capacity of about 2,000,000,000 gallons. The area of the water-shed directly tributary to the reservoir is limited, but by a system of canals water is conveyed to the reservoir from Jabish, Broad, Axe Factory and Higher brooks, so that the total tributary water-shed is a little over 20 square miles. Water is also pumped at times from Chapin Pond in Ludlow and from Loon and Five Mile ponds in Springfield into one of the two mains leading from Ludlow Reservoir to the city.

Ludlow Reservoir flows an area which was originally a swamp and has a muddy bottom covered largely with decaying stumps. The maximum depth of mud exceeds 40 feet. The reservoir has been affected in nearly every year since its construction by the presence of great numbers of organisms, chiefly *Anabæna,* which make the water unfit for domestic purposes during much of the warmer portion of the year. At such times the water of the canals and tributary water-sheds is diverted directly to a separate basin, and thence supplied to the city without passing through the reservoir. The quantity furnished by the canals is insufficient for the requirements of the city, and at such times water is pumped from Chapin, Loon or Five Mile Pond.

The cause of the objectionable quality of the water of Ludlow Reservoir was investigated soon after its completion in 1875, and possible methods for improving it have been considered by the State Board of Health from time to time, especially since 1889. Experiments upon the purification of the water by filtration were made by the Springfield water department in co-operation with the State Board of Health in 1901, the results of which will be found in the report of that year; and further experiments in the same general line were made by the Springfield water department in the year 1903.

In the latter part of 1904 a scheme was presented to the Board for its advice, which provided for developing a water supply for the city of Springfield by constructing additional reservoirs within the water-sheds of streams tributary to Ludlow Reservoir, and subsequently increasing the supply by taking water from Twelve Mile Brook in the town of Monson and tributaries of Scantic River in the town of Hampden, involving the construction of several storage reservoirs and the filtra-

tion of the water of Ludlow Reservoir and possibly of the other sources mentioned. The reply of the Board to this communication will be found on page 86 of this report.

In the latter part of the year plans were presented to the Board for its consideration, which provide for taking water for the supply of the city from Westfield Little River in the town of Blandford.

Waltham. — The Waltham water works were constructed in 1873. The original source of supply was a filter basin located near the northerly bank of Charles River, on a point extending into the stream and between 65 and 70 feet from the edge of the water. The bottom of this basin was originally 8.4 feet below the level of the water in the river. In 1891 a well 40 feet in diameter was sunk in the bottom of the filter basin to a further depth of 18 feet, or 26.4 feet below the average level of the water in the river. Both the filter basin and well were covered at the time the new well was constructed, and since that time all of the water supplied to the city has been drawn from this source.

The consumption of water increased very rapidly, from a little over 600,000 gallons per day in 1890 to somewhat over 2,400,000 gallons in 1902. Since 1902 the consumption has been reduced, by restriction of waste and leakage, to about 2,073,000 gallons per day in 1904.

The water of this source is evidently derived in part from the rainfall upon the very porous gravelly soil in the neighborhood of the well, and in part by the filtration of water through the ground from Charles River.

The source has now been in use for a period of thirty-two years since the original filter-gallery was constructed, and fourteen years since it was deepened, and records of analyses of the water in nearly every year since 1887 are now available. The most notable feature of these analyses is a gradual deterioration in the quality of the water, which has become very marked in the past five years, indicating an increasing inefficiency in the purification of the water passing through the ground to the well. This increasing deterioration is best illustrated by an examination of the analyses on page 172 and the accompanying diagram, which show the quantity of free and albuminoid ammonia and iron present in the water each year, as shown by the averages of monthly analyses. The marked increase in the quantity of water drawn from the well and filter-gallery during these years is also shown upon this diagram.

In response to requests from the Waltham water department for advice as to possible methods of arresting the deterioration in the quality of the water, the Board has advised the introduction of water from some auxiliary source in a sufficient quantity to reduce the draft from

the filter-gallery to the amount drawn before serious deterioration began; and in the present year a plan has been submitted to the Board, providing for the construction of a well about 1,100 feet up stream from the present filter-gallery for use as an additional source of supply, with a view to reducing the draft from the present source. An examination of the proposed location of this well, however, showed that the ground water in that locality was already being drawn toward the present well, and that the conditions were not favorable for obtaining a large additional supply of good water or reducing materially the draft from the ground about the present filter-gallery; and the Board advised taking water from a point farther up stream or that water be introduced from another source. A copy of this advice will be found on page 101.

Wellesley. — The sources of supply are a filter-gallery in the valley of Rosemary Brook about 400 feet from Charles River, a well near Rosemary Brook a short distance above the filter-gallery, and a system of tubular wells still farther up the valley of the brook. There is a considerable population in the valley of Rosemary Brook above the wells, but there are no houses in their immediate vicinity.

The character of the water of the wells has changed materially since water was first drawn from them, in 1898, the great increase in the quantity of chlorine and nitrates present indicating that water is now being drawn in part from an area which receives sewage pollution.

The yearly averages of analyses of samples of the water from these wells may be found on page 173.

Whitman. — Water was first introduced by the town in the year 1883. From that time until Jan. 1, 1905, the public water supply was obtained from Hobart's Pond, a mill pond in the village within the water-shed of which are located the large villages of Abington and North Abington, together with a portion of the village of Whitman. In January, 1905, the use of this source was abandoned and connection made with the works of the city of Brockton, by which the town is now supplied wholly with water from Silver Lake.

Williamsburg. — Works for supplying the town of Williamsburg with water were constructed by the town in 1903. The source of supply is Unquomonk Brook, the water being taken from a small intake reservoir and supplied to the town by gravity. The water-shed of the brook above the intake reservoir has an area of .9 of a square mile and contains two or three houses, none of which is situated near the stream. About 1,600 feet above the intake reservoir a storage reservoir has been constructed having an area of 2.9 acres and a capacity of 8,000,000 gallons.

Winchendon. — The source of supply is a well 29 feet in diameter

and 26 feet deep, on the north bank of Miller's River. A line of 12-inch pipe, with 6-inch branches, was laid with open joints through the low land in the vicinity of the well for the purpose of collecting an additional supply of ground water.

The water has deteriorated rapidly since 1897, when the works were completed, iron now being present in sufficient quantity to be noticeable and to make the water objectionable for certain domestic purposes.

The yearly averages of analyses of samples of the water from this well may be found on page 173.

Averages of Chemical Analyses of Surface-water Sources for the Year 1905.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
				Free.	Albuminoid. Total.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
Metropolitan Water District.	Wachusett Reservoir, upper end.	0.52	3.69	.0024	.0210	.0041	0.29	.0061	.0001	0.58	0.8
	Wachusett Reservoir, surface, near dam.	0.21	3.30	.0029	.0149	.0026	0.26	.0048	.0001	0.35	0.9
	Wachusett Reservoir, bottom, near dam.	0.21	3.07	.0027	.0121	.0022	0.22	.0067	.0001	0.32	0.7
	Wachusett Aqueduct, .	0.42	3.99	.0038	.0191	.0022	0.28	.0104	.0001	0.57	1.1
	Sudbury Reservoir, .	0.20	3.57	.0046	.0147	.0020	0.30	.0073	.0001	0.35	1.1
	Framingham Reservoir No. 3.	0.19	3.26	.0030	.0147	.0027	0.28	.0062	.0002	0.30	1.1
	Hopkinton Reservoir, .	0.63	4.00	.0055	.0190	.0027	0.37	.0110	.0002	0.74	0.9
	Ashland Reservoir, .	0.69	4.11	.0031	.0211	.0021	0.32	.0066	.0001	0.81	1.0
	Framingham Reservoir No. 2.	0.79	4.28	.0044	.0228	.0022	0.32	.0052	.0002	0.87	0.9
	Lake Cochituate, . .	0.25	4.80	.0026	.0213	.0046	0.50	.0049	.0001	0.42	1.8
	Chestnut Hill Reservoir.	0.22	3.49	.0036	.0165	.0033	0.29	.0068	.0001	0.33	1.1
	Spot Pond, . . .	0.16	3.84	.0020	.0166	.0023	0.36	.0025	.0001	0.30	1.4
	Tap in State House, .	0.23	3.86	.0020	.0145	.0021	0.35	.0083	.0001	0.35	1.4
	Tap in Revere, . .	0.14	3.44	.0021	.0140	.0019	0.32	.0038	.0000	0.27	1.4
	Tap in Quincy, . .	0.20	3.83	.0017	.0135	.0015	0.34	.0103	.0001	0.34	1.5
Abington, . .	Big Sandy Pond, . .	0.11	3.12	.0025	.0139	.0013	0.66	.0027	.0000	0.17	0.6
Amherst, . .	Amethyst Brook Reservoir.	0.41	3.49	.0013	.0119	.0019	0.14	.0027	.0000	0.50	0.5
Andover, . .	Haggett's Pond, . .	0.13	3.34	.0014	.0139	.0007	0.32	.0030	.0000	0.28	1.1
Ashfield, . . .	Bear Swamp Brook, .	0.22	4.75	.0013	.0074	.0009	0.09	.0030	.0000	0.33	2.5
Athol, . . .	Phillipston Reservoir, .	0.71	3.65	.0165	.0461	.0165	0.14	.0044	.0001	0.89	0.6
	Buckman Brook Reservoir.	0.35	3.76	.0051	.0259	.0078	0.14	.0057	.0000	0.57	0.7
Brockton, . .	Salisbury Brook Reservoir.[1]	0.50	4.07	.0038	.0262	.0058	0.47	.0032	.0000	0.72	0.7
	Silver Lake, . . .	0.10	3.18	.0020	.0122	.0021	0.61	.0019	.0000	0.22	0.6

[1] Not used.

Averages of Chemical Analyses of Surface-water Sources, etc. — Continued.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Cambridge, . .	Upper Hobbs Brook Reservoir.	0.60	5.62	.0051	.0354	.0074	0.39	.0068	.0001	0.80	2.0
	Lower Hobbs Brook Reservoir.	0.12	4.66	.0035	.0233	.0029	0.38	.0032	.0001	0.37	2.2
	Stony Brook Reservoir,	0.44	5.30	.0037	.0227	.0031	0.45	.0129	.0002	0.56	2.0
	Fresh Pond, . . .	0.24	7.20	.0129	.0295	.0097	0.66	.0145	.0006	0.36	3.2
Cheshire, . . .	Thunder Brook, . .	0.02	5.47	.0029	.0059	.0007	0.09	.0090	.0000	0.08	3.7
	Kitchen Brook, . .	0.03	4.75	.0021	.0058	.0011	0.07	.0057	.0000	0.10	3.2
Chicopee, . .	Morton Brook, . .	0.06	3.78	.0013	.0048	.0011	0.13	.0057	.0000	0.06	0.7
	Cooley Brook, . .	0.46	4.00	.0030	.0181	.0074	0.15	.0057	.0001	0.49	0.9
Concord, . . .	Sandy Pond, . . .	0.04	2.11	.0026	.0146	.0039	0.27	.0057	.0000	0.12	0.6
Dalton, . . .	Egypt Brook Reservoir,	0.36	3.00	.0027	.0151	.0025	0.07	.0177	.0001	0.55	0.8
Danvers, . . .	Middleton Pond, . .	0.51	3.55	.0023	.0184	.0025	0.34	.0027	.0001	0.69	0.9
Deerfield, . .	Roaring Brook, . .	0.07	6.37	.0012	.0055	.0006	0.10	.0080	.0001	0.11	3.8
Easthampton, . .	Bassett Brook, . .	0.32	4.17	.0010	.0117	.0024	0.11	.0087	.0000	0.34	1.3
Fall River, . .	North Watuppa Lake, .	0.18	3.39	.0018	.0174	.0029	0.59	.0027	.0001	0.33	0.7
Falmouth, . .	Long Pond, . . .	0.00	2.67	.0013	.0101	.0017	0.92	.0030	.0000	0.09	0.4
Fitchburg, . .	Meetinghouse Pond, .	0.07	2.33	.0029	.0115	.0020	0.14	.0022	.0000	0.20	0.5
	Scott Reservoir, . .	0.18	2.24	.0039	.0159	.0030	0.13	.0029	.0000	0.31	0.4
Gardner, . . .	Crystal Lake, . .	0.06	3.97	.0025	.0187	.0022	0.32	.0033	.0001	0.19	1.4
Gloucester, . .	Dike's Brook Reservoir,	0.45	4.03	.0048	.0192	.0035	0.98	.0026	.0000	0.43	0.4
	Wallace Reservoir, .	0.40	4.50	.0039	.0220	.0060	1.23	.0010	.0000	0.45	0.4
	Haskell Brook Reservoir.	0.58	4.38	.0143	.0185	.0024	1.00	.0025	.0001	0.48	0.4
Greenfield, . .	Glen Brook Reservoir,	0.04	5.04	.0020	.0086	.0011	0.14	.0095	.0000	0.12	3.1
Hatfield, . . .	Reservoir, . . .	0.08	4.22	.0011	.0045	.0002	0.13	.0170	.0000	0.10	1.6
Haverhill, . .	Johnson's Pond, . .	0.16	4.43	.0017	.0169	.0012	0.38	.0020	.0000	0.29	1.9
	Crystal Lake, . .	0.20	2.97	.0018	.0160	.0013	0.28	.0022	.0001	0.34	0.9
	Kenoza Lake, . .	0.15	3.93	.0020	.0160	.0024	0.40	.0032	.0000	0.29	1.5
	Lake Saltonstall, . .	0.06	5.44	.0015	.0158	.0022	0.58	.0013	.0001	0.17	2.3
	Millvale Reservoir, .	0.67	5.16	.0036	.0237	.0035	0.35	.0032	.0001	0.82	1.6
Hingham, . .	Accord Pond, . .	0.13	2.61	.0015	.0109	.0019	0.58	.0021	.0000	0.26	0.3
Holyoke, . . .	Whiting Street Reservoir.	0.13	4.57	.0052	.0358	.0184	0.15	.0037	.0001	0.24	2.6
	Manhan Brook, . .	0.26	3.81	.0026	.0119	.0026	0.16	.0032	.0000	0.37	1.4
	Tucker Brook, . .	0.30	2.92	.0020	.0108	.0022	0.13	.0027	.0000	0.37	0.4
	Wright and Ashley Pond.	0.11	4.44	.0070	.0208	.0027	0.13	.0047	.0000	0.24	2.3
	High-service Reservoir,	0.18	4.55	.0033	.0210	.0040	0.17	.0065	.0001	0.37	2.2

Averages of Chemical Analyses of Surface-water Sources, etc. — Continued.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Hudson, . . .	Gates Pond, . . .	0.09	2.32	.0041	.0138	.0021	0.20	.0043	.0001	0.23	0.5
Ipswich, . . .	Dow's Brook Reservoir,	0.19	4.91	.0020	.0187	.0027	0.66	.0032	.0000	0.32	1.7
Lawrence, . .	Merrimack River, filtered.	0.44	4.95	.0115	.0104	.0007	0.33	.0165	.0001	0.51	1.5
	Distributing Reservoir,	0.36	4.84	.0065	.0115	.0017	0.34	.0191	.0002	0.46	1.7
Lee, ...	Codding Brook, . .	0.22	3.73	.0022	.0098	.0009	0.09	.0087	.0001	0.30	1.5
Lenox, . . .	Reservoir, . . .	0.08	4.85	.0020	.0124	.0030	0.08	.0090	.0002	0.13	3.5
Leominster, . .	Morse Reservoir, . .	0.17	2.16	.0022	.0170	.0034	0.15	.0026	.0000	0.33	0.2
	Haynes Reservoir, .	0.14	2.39	.0064	.0317	.0101	0.15	.0020	.0001	0.35	0.2
	Fall Brook Reservoir, .	0.15	2.13	.0024	.0188	.0042	0.16	.0018	.0000	0.28	0.3
Lynn, . . .	Birch Reservoir, . .	0.46	4.84	.0118	.0255	.0051	0.64	.0042	.0000	0.64	1.5
	Breed's Reservoir, .	0.40	3.92	.0045	.0215	.0028	0.56	.0031	.0000	0.52	0.9
	Glen Lewis Reservoir,	0.23	3.05	.0038	.0268	.0038	0.46	.0012	.0000	0.40	0.3
	Walden Reservoir, .	0.54	4.86	.0167	.0267	.0040	0.60	.0078	.0001	0.75	1.5
	Hawkes Reservoir, .	0.83	6.53	.0065	.0342	.0035	0.72	.0044	.0001	1.03	2.2
	Saugus River, . .	0.99	7.39	.0065	.0382	.0041	0.75	.0037	.0001	1.22	2.8
Marlborough, . .	Lake Williams, . .	0.10	4.03	.0044	.0211	.0041	0.52	.0038	.0001	0.25	1.5
	Millham Brook Reservoir.	0.63	4.38	.0047	.0249	.0046	0.34	.0095	.0002	0.67	1.1
Maynard, . .	White Pond, . . .	0.01	2.43	.0012	.0137	.0025	0.32	.0043	.0000	0.14	0.3
Milford, . . .	Charles River, filtered,	0.26	3.88	.0007	.0079	–	0.31	.0155	.0000	0.31	0.9
Montague, . .	Lake Pleasant, . .	0.03	2.29	.0026	.0078	.0011	0.12	.0030	.0000	0.07	0.5
Nantucket, . .	Wannacomet Pond, .	0.15	6.22	.0038	.0276	.0111	2.09	.0007	.0000	0.18	1.0
Needham, . .	Basin near pumping station.[1]	0.26	4.08	.0018	.0259	.0090	0.49	.0168	.0002	0.39	1.1
New Bedford, . .	Old Storage Reservoir,[1]	1.27	5.27	.0040	.0263	.0030	0.59	.0032	.0001	1.27	1.0
	Little Quittacas Pond, .	0.28	3.51	.0022	.0163	.0018	0.55	.0015	.0000	0.46	0.6
	Great Quittacas Pond,	0.43	3.62	.0020	.0174	.0017	0.55	.0007	.0000	0.64	0.6
North Adams, . .	Notch Brook Reservoir,	0.04	6.55	.0052	.0076	.0018	0.07	.0040	.0000	0.10	3.9
	Broad Brook, . .	0.22	3.44	.0028	.0088	.0010	0.07	.0132	.0000	0.36	1.5
Northampton, . .	Middle Reservoir, .	0.15	3.56	.0021	.0124	.0024	0.12	.0060	.0000	0.27	1.5
	Mountain Street Reservoir.	0.09	3.61	.0019	.0082	.0012	0.09	.0037	.0000	0.18	1.6
North Andover, .	Great Pond, . . .	0.13	3.52	.0023	.0190	.0023	0.36	.0033	.0000	0.28	1.2
Northborough, .	Lower Reservoir, . .	0.70	4.32	.0050	.0204	.0024	0.27	.0067	.0001	0.73	0.9
Northbridge, . .	Cook Allen Reservoir, .	0.28	2.54	.0026	.0131	.0018	0.20	.0030	.0000	0.40	0.4
North Brookfield, .	Doane Pond, . . .	0.48	3.17	.0057	.0218	.0036	0.15	.0047	.0001	0.46	0.5
	North Pond,[1] . . .	0.52	3.33	.0081	.0317	.0093	0.15	.0055	.0001	0.58	0.6

[1] Not used.

Averages of Chemical Analyses of Surface-water Sources, etc. — Continued.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Norwood,	Buckmaster Pond,	0.11	3.38	.0094	.0137	.0024	0.44	.0035	.0001	0.16	0.7
Palmer,	Lower Reservoir,	0.30	3.69	.0032	.0164	.0031	0.15	.0028	.0000	0.41	0.8
Peabody,	Brown's Pond,	0.12	3.44	.0047	.0195	.0036	0.66	.0049	.0000	0.24	0.7
	Spring Pond,	0.09	5.52	.0112	.0117	.0017	0.62	.0056	.0001	0.13	1.9
	Reservoir,	0.07	5.42	.0062	.0114	.0016	0.70	.0279	.0003	0.11	1.9
Plymouth,	Little South Pond,	0.01	2.45	.0009	.0134	.0017	0.70	.0017	.0000	0.10	0.2
Randolph,	Great Pond,	0.39	4.29	.0013	.0169	.0018	0.66	.0047	.0000	0.52	1.0
Rockport,	Cape Pond,	0.32	8.88	.0147	.0440	.0185	3.11	.0040	.0001	0.39	1.4
Rutland,	Muschopauge Lake,	0.05	2.11	.0016	.0101	.0011	0.20	.0040	.0000	0.13	0.6
Salem,	Wenham Lake,	0.17	5.65	.0059	.0223	.0056	0.84	.0059	.0002	0.31	2.2
	Longham Reservoir,	1.00	7.14	.0168	.0356	.0103	1.03	.0104	.0003	0.95	1.9
Southbridge,	Hatchet Brook Reservoir.	0.52	3.43	.0043	.0193	.0051	0.15	.0043	.0000	0.62	0.7
South Hadley,	Leaping Well Reservoir.	0.08	2.65	.0048	.0195	.0067	0.14	.0042	.0001	0.11	0.7
	Buttery Brook Reservoir.	0.10	3.72	.0060	.0081	.0016	0.26	.0302	.0002	0.12	0.7
Spencer,	Shaw Pond,	0.07	2.90	.0073	.0231	.0019	0.21	.0037	.0001	0.16	0.9
Springfield,	Jabish Canal,	0.37	3.75	.0021	.0138	.0021	0.15	.0044	.0001	0.42	1.0
	Axe Factory Brook,	0.40	4.15	.0021	.0146	.0017	0.19	.0048	.0000	0.53	1.4
	Higher Brook,	0.43	2.80	.0014	.0108	.0014	0.11	.0022	.0000	0.50	0.5
	Broad Brook,	0.43	4.53	.0018	.0121	.0015	0.16	.0049	.0001	0.50	1.3
	Broad Brook Canal,	0.37	3.17	.0025	.0136	.0028	0.14	.0051	.0000	0.44	0.8
	Ludlow Canal,	0.40	3.72	.0027	.0149	.0021	0.15	.0044	.0001	0.46	1.0
	Ludlow Reservoir,	0.23	2.74	.0050	.0226	.0078	0.14	.0056	.0001	0.30	0.7
	Chapin Pond,	0.07	2.24	.0019	.0179	.0035	0.11	.0032	.0000	0.20	0.4
	Five Mile Pond,	0.11	2.29	.0041	.0183	.0027	0.14	.0027	.0000	0.22	0.4
Stockbridge,	Lake Averic,	0.11	5.35	.0031	.0211	.0052	0.07	.0037	.0001	0.25	3.5
Taunton,	Assawompsett Pond,	0.28	3.33	.0022	.0179	.0023	0.55	.0030	.0000	0.45	0.5
	Elder's Pond,	0.10	2.90	.0017	.0169	.0020	0.51	.0021	.0000	0.29	0.5
	Long Pond,	0.84	4.16	.0026	.0204	.0026	0.57	.0012	.0000	1.00	0.5
Wakefield,	Crystal Lake,	0.19	4.47	.0046	.0161	.0034	0.61	.0040	.0000	0.34	1.5
Wareham,	Jonathan's Pond,	0.01	2.22	.0015	.0088	.0010	0.67	.0047	.0000	0.06	0.0
Wayland,	Snake Brook Reservoir,	0.79	4.30	.0075	.0320	.0068	0.29	.0055	.0001	0.85	1.2
Westborough,	Upper Sandra Pond,	0.22	2.76	.0041	.0218	.0059	0.23	.0027	.0000	0.37	0.4
Westfield,	Montgomery Reservoir,	0.42	2.50	.0045	.0218	.0040	0.12	.0020	.0000	0.51	0.4
	Tillotson Brook,	0.28	3.09	.0012	.0101	.0013	0.11	.0037	.0000	0.36	0.5

Averages of Chemical Analyses of Surface-water Sources, etc. — Concluded.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
West Springfield, .	Darby Brook Reservoir,	0.27	3.97	.0012	.0129	.0055	0.19	.0105	.0000	0.27	1.7
Weymouth, . .	Great Pond, . . .	0.61	3.77	.0032	.0179	.0023	0.58	.0037	.0000	0.67	0.4
Winchester, . .	North Reservoir, . .	0.08	3.75	.0057	.0167	.0018	0.44	.0030	.0001	0.19	1.8
	South Reservoir, . .	0.10	3.27	.0061	.0191	.0027	0.39	.0043	.0001	0.22	1.0
	Middle Reservoir, .	0.21	3.48	.0107	.0263	.0053	0.38	.0047	.0001	0.34	1.2
Woburn, . . .	Horn Pond,[1] . . .	0.29	7.48	.0041	.0289	.0083	0.92	.0288	.0005	0.44	2.8
Worcester, . .	Bottomly Reservoir, .	0.36	3.63	.0049	.0183	.0015	0.19	.0094	.0001	0.51	1.0
	Kent Reservoir, . .	0.17	3.14	.0019	.0142	.0028	0.19	.0072	.0000	0.28	1.0
	Leicester Reservoir, .	0.19	2.88	.0040	.0137	.0016	0.20	.0064	.0000	0.28	0.9
	Upper Holden Reservoir.	0.15	2.27	.0031	.0127	.0025	0.17	.0038	.0000	0.23	0.4
	Lower Holden Reservoir.	0.10	2.45	.0026	.0124	.0014	0.17	.0048	.0000	0.17	0.5

[1] Not used.

Averages of Chemical Analyses of Ground-water Sources for the Year 1905.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Adams, . . .	Tubular wells, . . .	.02	13.70	.0000	.0006	0.10	.0240	.0000	.00	6.1	.0000
Amesbury, . .	Main Street wells, . .	.19	10.11	.0011	.0012	0.67	.0402	.0001	.02	4.4	.1062
	Market Street wells, . .	.02	24.66	.0039	.0026	1.33	.0024	.0000	.04	12.9	.0082
Attleborough, .	Old well, ...	.04	4.60	.0010	.0041	0.41	.0076	.0000	.07	2.0	.0102
	New well, ...	.03	4.96	.0009	.0039	0.42	.0096	.0000	.06	2.0	.0098
Avon, ...	Well, ...	.03	3.82	.0001	.0008	0.42	.0315	.0000	.00	1.1	.0045
Ayer, ...	Well, ...	.00	5.03	.0006	.0025	0.37	.0277	.0000	.02	2.2	.0063
Billerica, . .	Tubular wells, . . .	.09	6.49	.0011	.0027	0.29	.0070	.0000	.09	2.2	.0432
Braintree, . .	Filter-gallery, . . .	.08	5.42	.0018	.0069	0.98	.0302	.0001	.15	1.8	.0122
Bridgewater, .	Wells, ...	.23	6.57	.0005	.0043	0.45	.0160	.0000	.13	2.1	.0963
Brookline, . .	Tubular wells and filter-gallery.	.11	9.27	.0042	.0062	0.61	.0325	.0002	.14	4.5	.0215
Canton, . . .	Springdale well, . . .	.04	3.75	.0002	.0013	0.39	.0095	.0000	.02	1.3	.0237
	Well near Henry's Spring,	.05	3.82	.0003	.0019	0.40	.0205	.0000	.08	1.2	.0057
Cohasset, . .	Tubular wells No. 1, . .	.09	14.60	.0002	.0018	1.69	.0400	.0000	.04	4.6	.0200

Averages of Chemical Analyses of Ground-water Sources, etc. — Continued.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
Cohasset,	Tubular wells No. 2,	.00	11.17	.0005	.0014	1.39	.0587	.0000	.02	4.7	.0050
	Filter-gallery,	.24	11.17	.2125	.0132	1.23	.0040	.0003	.37	4.8	.0320
Dedham,	Large well,	.02	5.85	.0008	.0020	0.57	.0400	.0000	.05	3.0	.0055
	Tap in pumping station,	.01	9.92	.0009	.0026	0.90	.1900	.0000	.04	3.8	.0077
Dracut (Collinsville),	Tubular wells,	.00	5.57	.0003	.0015	0.26	.0310	.0000	.03	2.4	.0127
Easton,	Well,	.00	5.02	.0003	.0018	0.58	.0530	.0000	.01	1.6	.0090
Fairhaven,	Tubular wells,	.42	5.70	.0009	.0080	0.96	.0245	.0000	.49	1.8	.0115
Foxborough,	Tubular wells,	.00	3.57	.0002	.0013	0.33	.0287	.0000	.01	0.7	.0160
Framingham,	Filter-gallery,	.05	8.57	.0055	.0082	0.92	.0200	.0003	.10	4.1	.0177
Groton,	Well,	.00	4.49	.0002	.0015	0.17	.0105	.0000	.00	2.1	.0095
Hingham,	Wells,	.03	5.14	.0009	.0022	0.69	.0140	.0000	.03	1.6	.0186
Hyde Park,	Tubular wells near Neponset River.	.12	11.67	.0137	.0050	1.56	.0695	.0004	.11	4.9	.0684
	Tubular wells near Mother Brook.	.15	7.88	.0005	.0065	0.95	.1165	.0000	.22	2.8	.0072
Kingston,	Tubular wells,	.00	4.37	.0001	.0011	0.74	.0093	.0000	.01	1.1	.0027
Lowell,	Boulevard wells (tubular),	.08	5.36	.0039	.0040	0.27	.0123	.0000	.09	1.8	.0402
Manchester,	Large well,	.00	11.03	.0003	.0007	1.80	.1767	.0000	.00	4.2	.0070
	Tubular wells,	.00	9.40	.0002	.0012	1.29	.1450	.0000	.02	2.6	.0040
Mansfield,	Well,	.00	2.77	.0003	.0006	0.28	.0053	.0000	.01	0.5	.0100
Marblehead,	Well No. 1,	.13	17.00	.0129	.0031	2.32	.0177	.0002	.07	6.7	.2850
	Well No. 2,	.15	15.04	.0222	.0027	1.58	.0037	.0002	.08	6.4	.4380
Merrimac,	Tubular wells,	.01	4.66	.0000	.0006	0.40	.0342	.0000	.01	1.6	.0152
Methuen,	Tubular wells,	.14	7.84	.0016	.0048	0.34	.0170	.0001	17	3.2	.0580
Middleborough,	Well,	.22	6.38	.0018	.0055	0.66	.0566	.0001	.14	2.3	.1170
Nantucket,	Wells,	.06	7.53	.0089	.0095	2.00	.0077	.0001	.12	2.2	.0827
Natick,	Well,	.00	8.13	.0006	.0015	0.53	.0335	.0000	.01	4.3	.0063
Needham,	Well No. 1,	.00	5.86	.0004	.0014	0.61	.0954	.0000	.01	2.1	.0030
	Well No. 2,	.00	5.60	.0002	.0015	0.63	.1010	.0000	.01	2.1	.0034
	Hicks Spring,[1]	.00	4.52	.0003	.0011	0.47	.0923	.0000	.01	1.5	.0045
Newton,	Tubular wells and filter-gallery.	.09	6.60	.0011	.0059	0.49	.0335	.0000	.17	2.7	.0137
No. Attleborough,	Old well,	.02	5.62	.0003	.0011	0.47	.0247	.0000	.02	2.2	.0272
	New well,	.01	3.67	.0002	.0011	0.29	.0060	.0000	.01	1.4	.0160
Provincetown,	Well,	–	11.13	.0151	.0190	2.43	.0048	.0000	.85	3.0	.6930
Reading,	Filter-gallery,	.53	7.86	.0098	.0093	0.55	.0054	.0000	.44	2.9	.2286
	Filtered water,	.19	14.07	.0079	.0079	0.54	.0041	.0005	.28	8.2	.0171

[1] Not used.

Averages of Chemical Analyses of Ground-water Sources, etc. — Concluded.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Scituate,	Wells,	.01	15.67	.0001	.0010	3.45	.1905	.0000	.02	4.6	.0082
Sharon,	Well,	.00	10.25	.0004	.0013	1.23	.2350	.0000	.01	3.3	.0060
Shirley,	Well,	.02	3.23	.0002	.0005	0.14	.0027	.0001	.01	0.3	.0353
Tisbury,	Well,	.00	4.55	.0001	.0004	1.03	.0052	.0000	.00	0.6	.0062
Walpole,	Tubular wells,	.00	4.22	.0002	.0007	0.35	.0277	.0000	.00	1.4	.0032
Waltham,	Well,	.13	8.03	.0035	.0037	0.64	.0255	.0000	.11	3.5	.0437
Ware,	Well,	.00	9.02	.0002	.0009	0.74	.3375	.0000	.02	3.0	.0070
Wellesley,	Tubular wells,	.01	8.05	.0003	.0010	0.78	.1487	.0000	.02	3.4	.0055
Weston,	Well,	.34	8.60	.0031	.0161	0.40	.0253	.0000	.62	3.5	.0057
Winchendon,	Well,	.03	3.02	.0008	.0014	0.13	.0058	.0000	.02	0.8	.0620
Woburn,	Filter-gallery,	.01	9.66	.0073	.0033	1.16	.0115	.0000	.06	4.8	.0038

The Deterioration of Ground-water Supplies.

At the end of the year 1905 the number of ground-water sources used for the purposes of public water supply in Massachusetts was 78. Normal ground waters are more satisfactory for water-supply purposes than most surface waters, on account of their attractive appearance and their freedom from color, taste or odor, their low temperature in summer and the greater safety in their use. In some cases, however, where a ground-water supply has been in use for a considerable period, and a larger quantity of water has been drawn from the ground, the quality of the water has deteriorated after a time, the deterioration being indicated chiefly by an increase in the quantity of iron and ammonia and the presence of turbidity and color, which, in some cases, have been sufficient to make the water unfit for many domestic purposes. In one case (Bradford) the quality of the water became so bad that the source of supply was abandoned; and in another case (Reading) the water is treated with chemicals and filtered for the removal of iron.

The deterioration is usually most marked in those sources which are located near a pond or stream, the water being derived in such cases in part from the rain which falls upon and sinks into the ground in the neighborhood of the collecting works, and in part by percolation through the ground from the neighboring surface source. The deterioration in

such cases is due chiefly to the gradual reduction in the efficiency of the filtration of the water which passes through the soil from the pond or stream, and is especially likely to occur when the distance from the surface source to the collecting works is short. Deterioration increases ordinarily with the quantity drawn, probably because the lowering of the level of the water in the ground causes a more rapid infiltration from the surface source.

Iron is frequently present in water which has passed through peat and other soil containing a large quantity of organic matter, and which has not been subsequently purified in its passage through sand or gravel to the collecting works; and in some cases the deterioration of ground waters has been due to the reduction in the efficiency of the filtration of water which has taken up organic matter and iron from peat or muck near the surface of the ground. An example of such deterioration is found in Billerica, where the wells are located in the midst of an extensive meadow which contains at the surface a deep deposit of organic matter.

Still another cause for the deterioration of ground waters is the extension of the area from which water is drawn to the collecting works, with the increased draft from the source. In a few cases the water obtained from the ground in the immediate vicinity of the collecting works was at first of good quality, but the water obtained subsequently, after water had begun to reach the wells from a greater distance, has been affected by population or other causes. An example of such deterioration may be found in the tubular wells at Wellesley, where there is no pollution in the immediate vicinity of the wells, but the chlorine has increased about 50 per cent. in eight years, due probably in part at least to drawing water from a populated area at a considerable distance from the wells.

In the following tables the yearly averages of analyses of certain of the ground-water sources which have deteriorated rapidly are given; and, where such information is available, the quantity of water pumped from the source each year is also presented. In some cases the deterioration has been slight and is not yet noticeable by the consumers of the water, while in other cases the water has become objectionable for many domestic uses. The analyses of water from the filter-gallery at Reading and from the well at Provincetown are not included in the tables, though these waters have contained for many years an excessive quantity of iron, which in the case of Reading is removed by filtration. A description of the sources of supply is given on pages 141 to 159.

The effect of the draft from the sources upon the quality of the water is well shown in the analyses of water from the wells near Neponset

River at Hyde Park and from the "Boulevard wells" at Lowell. At Hyde Park a new source of supply was introduced in 1901, and the town of Milton, which had been supplied from the Hyde Park works, began to take its supply from the works of the Metropolitan Water District early in 1902, so that in that year it was possible to make a material reduction in the draft from the old wells. This reduction in the draft was followed by a great improvement in the character of the water. At Lowell a great improvement was made in the quality of the water drawn from the ground in the vicinity of Merrimack River by an extension of the collecting works. In both of these cases the improvement has been temporary and the deterioration has subsequently continued.

Yearly Averages of Chemical Analyses of Samples from Ground-water Sources.

Amesbury. — Main Street Wells.

[Parts per 100,000.]

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
1901, ...	–	.10	10.73	.0009	.0013	0.60	.0390	.0001	.04	4.7	.0408
1902, ...	–	.10	10.12	.0015	.0011	0.81	.1075	.0002	.04	4.3	.0377
1903, ...	–	.08	10.59	.0033	.0023	0.95	.1110	.0004	.04	4.1	.0695
1904, ...	–	.09	9.87	.0017	.0012	0.75	.0690	.0001	.02	4.4	.0802
1905, ...	–	.19	10.11	.0011	.0012	0.67	.0402	.0001	.02	4.4	.1062

Billerica. — Tubular Wells.

1899, ...	–	.03	5.65	.0002	.0012	0.24	.0084	.0000	.04	2.0	.0101
1900, ...	52,000	.04	6.20	.0008	.0021	0.27	.0081	.0000	.05	2.3	.0252
1901, ...	58,000	.06	6.23	.0007	.0026	0.27	.0113	.0000	.06	2.2	.0280
1902, ...	74,000	.09	7.22	.0009	.0031	0.26	.0087	.0000	.08	2.3	.0287
1903, ...	80,000	.08	6.57	.0012	.0027	0.26	.0065	.0000	.10	2.4	.0435
1904, ...	102,000	.05	6.27	.0009	.0026	0.28	.0052	.0000	.09	2.2	.0382
1905, ...	81,000	.09	6.49	.0011	.0027	0.29	.0070	.0000	.09	2.2	.0432

Yearly Averages of Chemical Analyses of Samples, etc. — Continued.

Brookline. — Tubular Wells and Filter-gallery.

[Parts per 100,000.]

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1888, ...	848,000	.04	6.76	.0002	.0049	0.52	.0326	.0000	–	–	–
1895, ...	1,318,000	.02	9.15	.0005	.0026	0.60	.0361	.0000	.07	4.4	.0022
1896, ...	1,348,000	.03	8.48	.0007	.0031	0.57	.0302	.0000	.10	4.6	.0018
1897, ...	1,382,000	.03	9.02	.0015	.0041	0.56	.0358	.0000	.10	4.6	.0012
1898, ...	1,472,000	.07	8.85	.0012	.0041	0.56	.0321	.0001	.13	4.3	.0032
1899, ...	1,772,000	.03	8.65	.0020	.0032	0.56	.0315	.0002	.09	4.2	.0022
1900, ...	1,941,000	.01	9.25	.0029	.0034	0.58	.0403	.0002	.09	4.5	.0068
1901, ...	1,902,000	.03	8.70	.0033	.0048	0.55	.0359	.0002	.08	4.4	.0070
1902, ...	1,961,000	.03	9.32	.0036	.0040	0.58	.0361	.0002	.06	4.7	.0084
1903, ...	2,116,000	.07	8.75	.0039	.0044	0.56	.0280	.0003	.13	4.7	.0165
1904, ...	2,348,000	.05	9.07	.0043	.0039	0.62	.0409	.0001	.12	4.9	.0230
1905, ...	2,273,000	.11	9.27	.0042	.0062	0.61	.0325	.0002	.14	4.5	.0215

Fairhaven. — Tubular Wells.

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1894, ...	–	.04	6.19	.0004	.0024	0.98	.0903	.0002	.07	1.8	.0138
1895, ...	70,000	.13	5.52	.0001	.0042	1.02	.0587	.0001	.20	1.7	.0076
1896, ...	110,000	.28	6.02	.0004	.0055	1.01	.0366	.0000	.32	1.9	.0116
1897, ...	172,000	.18	5.56	.0005	.0044	1.01	.0361	.0001	.19	1.9	.0143
1898, ...	211,000	.16	5.33	.0002	.0042	0.83	.0362	.0001	.20	1.7	.0088
1900, ...	213,000	.15	5.95	.0003	.0067	0.82	.0372	.0001	.33	1.6	.0130
1901, ...	206,000	.20	6.57	.0002	.0072	0.83	.0443	.0001	.28	2.1	.0088
1902, ...	278,000	.45	6.24	.0004	.0104	0.92	.0248	.0000	.61	1.7	.0066
1903, ...	354,000	.48	6.34	.0014	.0105	1.00	.0232	.0000	.60	2.0	.0220
1904, ...	336,000	.53	6.36	.0017	.0121	0.98	.0236	.0001	.70	2.0	.0254
1905, ...	306,000	.42	5.70	.0009	.0080	0.96	.0245	.0000	.49	1.8	.0115

Yearly Averages of Chemical Analyses of Samples, etc. — Continued.

Framingham. — Filter-gallery.

[Parts per 100,000.]

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
1888,	171,000	.10	–	.0027	.0081	0.44	.0308	.0004	–	–	–
1889,	163,000	.00	–	.0031	.0050	0.56	.0366	.0002	–	–	–
1890,	204,000	.00	7.09	.0020	.0039	0.65	.0631	.0001	–	–	–
1891,	221,000	.00	6.25	.0023	.0035	0.63	.0707	.0001	–	2.8	–
1893,	282,000	.04	6.07	.0026	.0033	0.62	.0460	.0001	.11	2.6	.0099
1894,	321,000	.03	6.75	.0025	.0043	0.79	.0515	.0001	.08	2.8	.0272
1895,	362,000	.04	7.32	.0020	.0049	0.92	.0230	.0000	.07	3.0	.0130
1896,	376,000	.04	7.37	.0022	.0040	0.91	.0317	.0002	.04	3.2	.0145
1897,	322,000	.04	7.00	.0021	.0076	1.00	.0245	.0001	.06	3.3	.0072
1898,	344,000	.05	7.46	.0030	.0065	0.90	.0303	.0001	.09	3.2	.0090
1899,	416,000	.02	7.57	.0030	.0044	0.85	.0382	.0003	.05	3.2	.0047
1900,	433,000	.03	7.37	.0030	.0048	0.84	.0275	.0003	.07	3.3	.0147
1901,	447,000	.00	8.13	.0031	.0050	0.85	.0322	.0004	.06	3.7	.0087
1902,	420,000	.03	8.14	.0034	.0041	0.82	.0456	.0002	.05	3.6	.0158
1903,	524,000	.02	8.44	.0035	.0041	0.85	.0399	.0004	.07	4.1	.0112
1904,	–	.02	8.75	.0036	.0071	0.87	.0232	.0002	.07	4.1	.0160
1905,	–	.05	8.57	.0055	.0082	0.92	.0200	.0003	.10	4.1	.0177

Hyde Park. — Tubular Wells near Neponset River.

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia, Free.	Ammonia, Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1888,	285,000	.00	6.06	.0001	.0023	0.75	.0641	.0002	–	–	–
1893,	628,000	.02	8.62	.0031	.0032	1.19	.0879	.0002	.10	3.7	.0112
1894,	587,000	.03	9.68	.0040	.0039	1.37	.0843	.0001	.09	3.9	.0175
1895,	616,000	.04	9.44	.0063	.0035	1.31	.0867	.0001	.09	4.0	.0149
1896,	785,000	.03	9.68	.0084	.0046	1.21	.0882	.0003	.11	4.1	.0141
1897,	714,000	.04	9.94	.0093	.0037	1.30	.1170	.0002	.08	4.2	.0089
1898,	833,000	.08	10.28	.0120	.0046	1.17	.1271	.0003	.12	4.4	.0113
1899,	876,000	.04	10.39	.0122	.0041	1.24	.1043	.0002	.10	4.2	.0107
1900,	614,000	.05	11.04	.0153	.0043	1.54	.1085	.0002	.10	4.6	.0340
1901,	766,000	.05	10.96	.0157	.0055	1.26	.1077	.0003	.08	4.5	.0312
1902,	344,000	.04	9.55	.0066	.0034	1.04	.1037	.0002	.08	3.9	.0158
1903,	284,000	.06	10.04	.0068	.0040	1.06	.0977	.0003	.11	4.3	.0393
1904,	392,000	.06	10.27	.0092	.0039	1.26	.0880	.0002	.07	4.6	.0501
1905,	438,000	.12	11.67	.0137	.0050	1.56	.0695	.0004	.11	4.9	.0684

Yearly Averages of Chemical Analyses of Samples, etc. — Continued.

Hyde Park. — Tubular Wells near Mother Brook.

[Parts per 100,000.]

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
1901, ...	346,000	.01	9.03	.0010	.0042	0.92	.2562	.0002	.08	3.5	.0067
1902, ...	661,000	.05	8.04	.0007	.0046	0.85	.2026	.0000	.09	3.0	.0068
1903, ...	736,000	.08	7.57	.0008	.0062	0.81	.1606	.0000	.19	2.7	.0072
1904, ...	624,000	.06	8.09	.0004	.0048	1.02	.1517	.0000	.14	3.3	.0069
1905, ...	682,000	.15	7.88	.0005	.0065	0.95	.1165	.0000	.22	2.8	.0072

Lowell. — Boulevard Wells.

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia, Free.	Ammonia, Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1896, ...	3,976,000	.01	4.36	.0044	.0019	0.30	.0452	.0001	.04	1.8	.0098
1897, ...	3,251,000	.09	4.55	.0096	.0032	0.24	.0255	.0001	.05	1.8	.0222
1898, ...	2,919,000	.13	4.43	.0105	.0030	0.27	.0247	.0000	.08	1.9	.0310
1899, ...	4,568,000	.13	4.56	.0103	.0034	0.28	.0203	.0001	.08	1.7	.0388
1900, ...	5,719,000	.10	4.29	.0089	.0043	0.26	.0149	.0001	.10	1.6	.0591
1901, ...	6,109,000	.02	4.23	.0041	.0031	0.25	.0147	.0001	.07	1.8	.0260
1902, ...	5,957,000	.07	4.03	.0043	.0035	0.21	.0166	.0000	.08	1.5	.0297
1903, ...	5,267,000	.03	4.09	.0037	.0027	0.23	.0230	.0002	.07	1.5	.0317
1904, ...	5,485,000	.03	4.14	.0033	.0033	0.25	.0121	.0001	.08	1.7	.0337
1905, ...	5,485,000	.08	5.36	.0039	.0040	0.27	.0123	.0000	.09	1.8	.0402

Marblehead. — Well No. 1.

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia, Free.	Ammonia, Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1891, ...	156,000	.00	20.42	.0008	.0023	4.73	.1121	.0005	–	8.7	–
1892, ...	203,000	.01	32.39	.0001	.0005	9.56	.1808	.0002	–	11.3	–
1894, ...	205,000	.02	13.46	.0071	.0018	2.13	.0829	.0001	.03	6.4	.0603
1895, ...	268,000	.06	15.05	.0011	.0016	2.27	.0350	.0000	.03	7.1	.0152
1896, ...	277,000	.09	15.72	.0021	.0028	1.67	.0365	.0005	.05	7.5	.0295
1897, ...	321,000	.09	15.42	.0024	.0025	1.62	.0356	.0000	.02	7.1	.0212
1898, ...	414,000	.11	14.78	.0100	.0028	1.67	.0383	.0003	.04	6.6	.1095
1899, ...	456,000	.05	14.19	.0145	.0023	1.54	.0242	.0001	.06	5.7	.2172
1900, ...	506,000	.12	16.67	.0160	.0035	2.36	.0178	.0001	.06	6.6	.2175
1901, ...	480,000	.10	17.89	.0154	.0029	2.12	.0290	.0001	.05	6.8	.1640
1902, ...	484,000	.07	17.56	.0121	.0022	2.27	.0222	.0002	.09	7.2	.1760
1903, ...	559,000	.06	16.65	.0142	.0023	2.25	.0189	.0002	.06	7.0	.1873
1904, ...	552,000	.06	16.16	.0122	.0020	2.36	.0188	.0002	.04	7.4	.2026
1905, ...	573,000	.13	17.00	.0129	.0031	2.32	.0177	.0002	.07	6.7	.2850

Yearly Averages of Chemical Analyses of Samples, etc. — Continued.

Methuen. — Tubular Wells.

[Parts per 100,000.]

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1895, ...	149,000	.06	7.44	.0001	.0030	0.26	.0062	.0000	.09	3.2	.0133
1896, ...	170,000	.06	7.58	.0005	.0015	0.25	.0065	.0001	.06	3.2	.0123
1897, ...	216,000	.06	7.04	.0002	.0038	0.27	.0032	.0003	.10	3.3	.0052
1898, ...	230,000	.07	6.72	.0002	.0028	0.32	.0158	.0001	.11	2.8	.0038
1900, ...	298,000	.08	7.48	.0003	.0046	0.34	.0220	.0000	.09	3.3	.0223
1901, ...	328,000	.06	7.67	.0002	.0059	0.34	.0217	.0000	.08	3.5	.0077
1902, ...	333,000	.11	7.32	.0007	.0056	0.32	.0193	.0000	.08	3.2	.0095
1903, ...	302,000	.10	7.96	.0006	.0042	0.32	.0120	.0001	.12	3.7	.0322
1904, ...	313,000	.10	7.73	.0006	.0042	0.34	.0183	.0001	.12	3.5	.0333
1905, ...	372,000	.14	7.84	.0016	.0048	0.34	.0170	.0001	.17	3.2	.0580

Middleborough. — Well.

1888, ...	88,000	.00	8.67	.0001	.0025	0.96	.1494	.0001	–	–	–
1895, ...	212,000	.06	6.74	.0001	.0028	0.74	.0687	.0000	.08	2.6	.0187
1896, ...	211,000	.18	6.54	.0003	.0038	0.72	.0565	.0000	.09	2.4	.0288
1897, ...	196,000	.09	6.28	.0006	.0039	0.71	.0580	.0000	.11	2.5	.0227
1898, ...	214,000	.16	6.78	.0008	.0044	0.75	.0687	.0001	.14	2.7	.0408
1899, ...	224,000	.15	6.54	.0010	.0037	0.69	.0684	.0000	.12	2.3	.0329
1900, ...	233,000	.15	5.99	.0012	.0037	0.69	.0592	.0000	.10	2.2	.0489
1901, ...	224,000	.19	6.47	.0014	.0053	0.67	.0762	.0000	.12	2.3	.0487
1902, ...	241,000	.22	6.26	.0026	.0054	0.62	.0490	.0001	.16	2.1	.0841
1903, ...	248,000	.16	6.21	.0029	.0048	0.63	.0504	.0001	.16	2.3	.0922
1904, ...	255,000	.16	5.92	.0028	.0041	0.64	.0479	.0000	.11	2.6	.1372
1905, ...	238,000	.22	6.38	.0018	.0055	0.66	.0566	.0001	.14	2.3	.1170

Newton. — Tubular Wells and Filter-gallery.

1893, ...	1,370,000	.03	5.08	.0004	.0019	0.38	.0194	.0000	.08	2.3	.0119
1894, ...	1,623,000	.03	5.99	.0001	.0021	0.40	.0157	.0000	.05	2.7	.0110
1895, ...	1,801,000	.03	5.85	.0001	.0023	0.42	.0230	.0000	.06	2.4	.0146
1896, ...	1,812,000	.02	5.70	.0007	.0024	0.41	.0260	.0000	.06	2.6	.0108
1897, ...	1,804,000	.04	5.80	.0005	.0027	0.46	.0350	.0000	.07	2.8	.0122
1898, ...	1,758,000	.04	6.18	.0002	.0024	0.47	.0364	.0000	.07	2.8	.0032

Yearly Averages of Chemical Analyses of Samples, etc. — Continued.

Newton. — Tubular Wells and Filter-gallery — Concluded.

[Parts per 100,000.]

Year.	Average Daily Quantity of Water drawn from Source (Gallons).	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
1899,	2,036,000	.02	5.84	.0005	.0028	0.45	.0292	.0000	.07	2.3	.0028
1900,	2,086,000	.02	5.77	.0004	.0030	0.45	.0242	.0000	.08	2.3	.0029
1901,	1,845,000	.03	6.18	.0002	.0045	0.43	.0435	.0000	.07	2.7	.0053
1902,	1,928,000	.04	5.84	.0006	.0032	0.45	.0436	.0000	.06	2.4	.0057
1903,	2,109,000	.03	5.99	.0007	.0029	0.43	.0404	.0000	.11	2.7	.0095
1904,	2,188,000	.03	6.33	.0010	.0033	0.50	.0372	.0000	.10	2.9	.0103
1905,	2,155,000	.09	6.60	.0011	.0059	0.49	.0335	.0000	.17	2.7	.0137
Waltham. — Well.											
1892,	919,000	.00	6.81	.0033	.0027	0.45	.0162	.0000	–	3.4	.0034
1893,	1,055,000	.01	6.86	.0036	.0022	0.47	.0179	.0000	.06	3.4	.0020
1894,	1,239,000	.02	6.75	.0028	.0019	0.51	.0192	.0000	.06	3.1	.0044
1895,	1,222,000	.03	7.15	.0036	.0024	0.53	.0198	.0000	.05	3.4	.0082
1896,	1,520,000	.03	7.36	.0034	.0018	0.55	.0194	.0000	.06	3.6	.0157
1897,	1,541,000	.04	7.15	.0031	.0035	0.57	.0222	.0001	.06	3.6	.0108
1898,	1,699,000	.07	7.31	.0034	.0028	0.59	.0280	.0000	.07	3.4	.0162
1899,	2,027,000	.03	7.22	.0024	.0027	0.58	.0371	.0000	.05	3.1	.0082
1900,	2,118,000	.02	6.69	.0015	.0053	0.55	.0259	.0000	.08	3.0	.0086
1901,	2,292,000	.04	6.94	.0025	.0045	0.56	.0296	.0000	.08	3.4	.0182
1902,	2,435,000	.09	7.28	.0043	.0038	0.59	.0243	.0000	.10	3.4	.0257
1903,	2,254,000	.05	7.20	.0030	.0031	0.58	.0277	.0000	.10	3.5	.0305
1904,	2,073,000	.08	7.58	.0040	.0036	0.61	.0272	.0000	.08	3.5	.0352
1905,	2,074,000	.13	8.03	.0035	.0037	0.64	.0255	.0000	.11	3.5	.0437
Wellesley. — Tubular Wells.											
1898,	–	.03	7.46	.0026	.0006	0.56	.0606	.0014	.02	2.8	.0068
1899,	–	.00	6.92	.0007	.0015	0.55	.0962	.0000	.02	2.7	.0022
1900,	–	.02	6.83	.0037	.0016	0.61	.0623	.0053	.03	2.9	.0068
1901,	–	.00	7.27	.0002	.0013	0.63	.1090	.0001	.01	3.3	.0045
1902,	–	.01	7.50	.0048	.0010	0.62	.1587	.0028	.01	3.2	.0100
1903,	–	.00	7.64	.0003	.0010	0.60	.1625	.0000	.02	3.3	.0076
1904,	–	.00	8.90	.0004	.0011	0.72	.2240	.0000	.01	3.9	.0107
1905,	–	.01	8.05	.0003	.0010	0.78	.1487	.0000	.02	3.4	.0055

Yearly Averages of Chemical Analyses of Samples, etc. — Concluded.

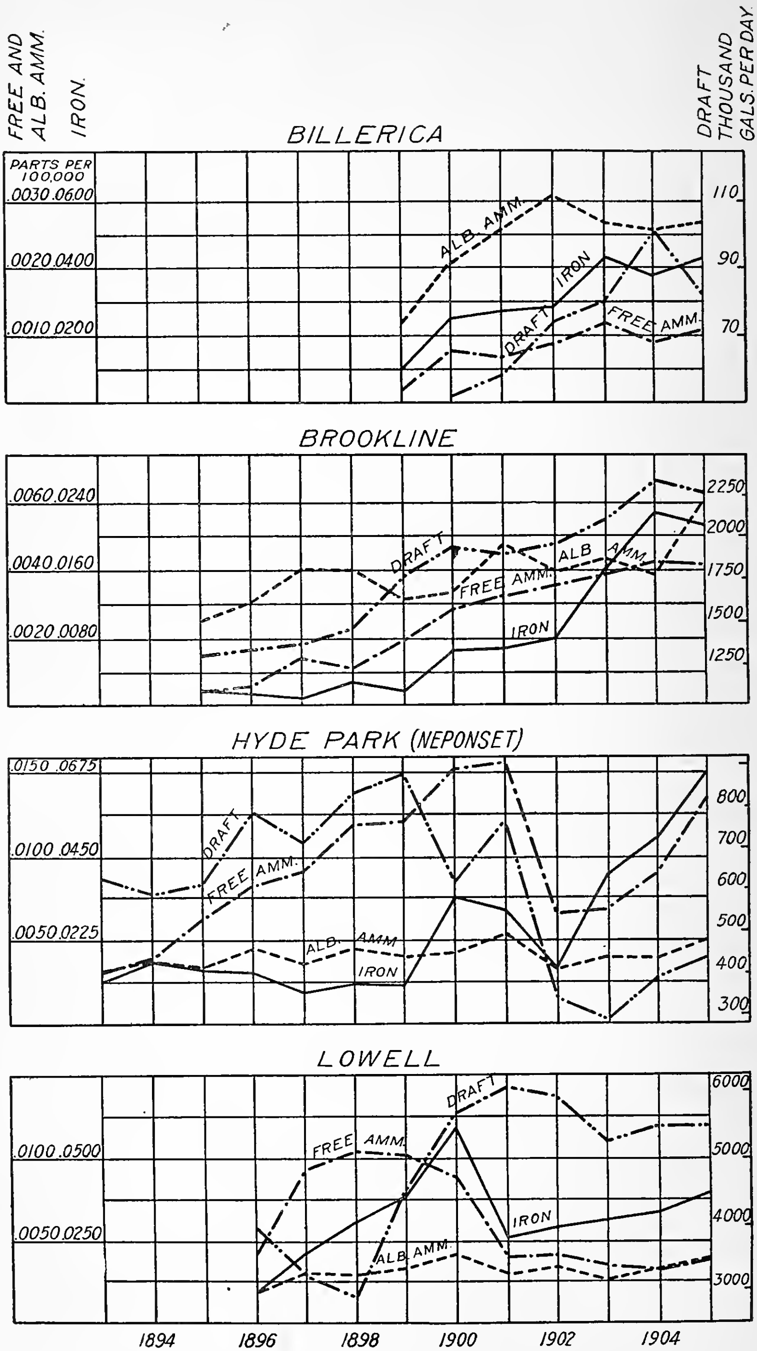
Winchendon. — *Well.*

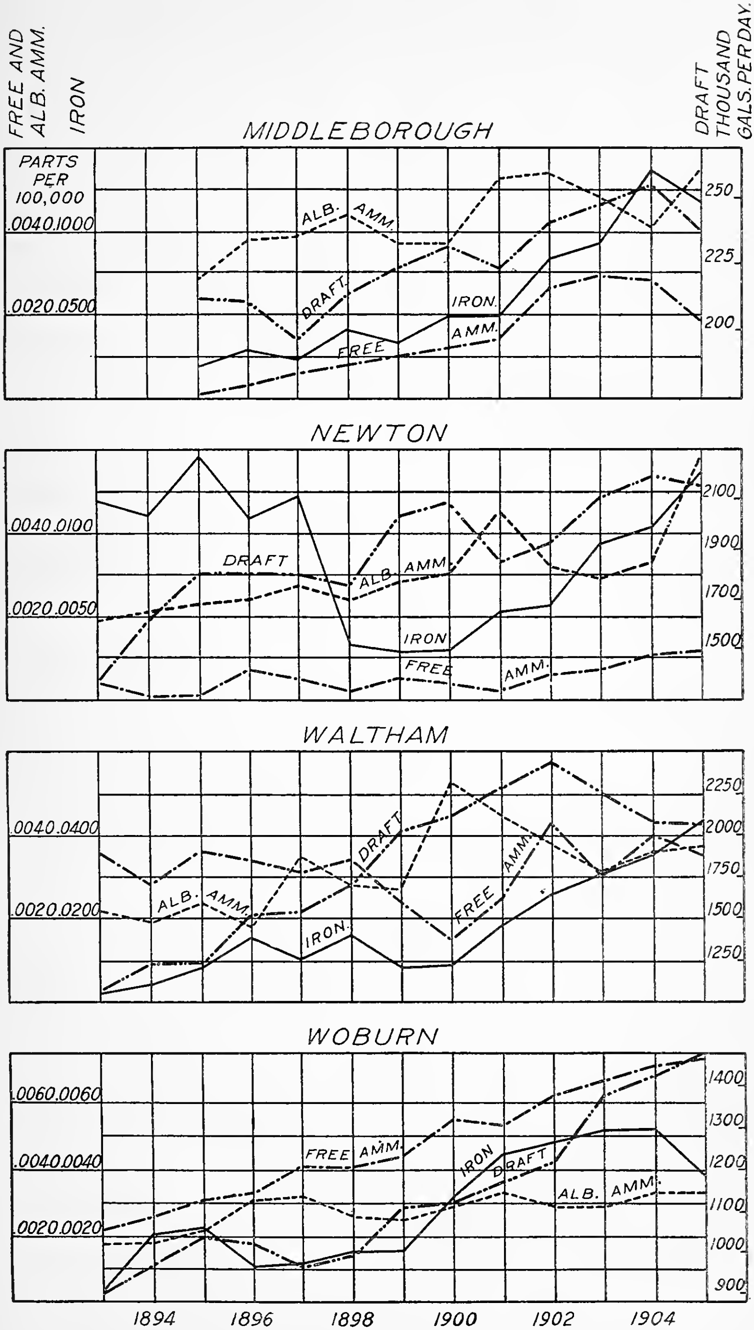
[Parts per 100,000.]

Year.	Average Daily Quantity of Water drawn from Source (Gallons.)	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albu-minoid.		Nitrates.	Nitrites.			
1897, ...	48,000	.02	3.43	.0006	.0019	0.12	.0040	.0000	.03	1.6	.0047
1898, ...	57,000	.07	3.40	.0004	.0014	0.11	.0037	.0000	.04	1.5	.0115
1900, ...	56,000	.00	2.85	.0006	.0009	0.11	.0045	.0000	.03	1.0	.0112
1901, ...	86,000	.00	3.17	.0009	.0015	0.12	.0038	.0000	.02	0.9	.0058
1902, ...	96,000	.01	3.15	.0020	.0013	0.12	.0040	.0000	.02	0.8	.0115
1903, ...	114,000	.01	2.97	.0029	.0027	0.11	.0050	.0000	.06	0.8	.0156
1904, ...	98,000	.07	3.10	.0012	.0019	0.11	.0053	.0000	.03	1.0	.0447
1905, ...	107,000	.03	3.02	.0008	.0014	0.13	.0058	.0000	.02	0.8	.0620

Woburn. — *Filter-gallery.*

Year.	Average Daily Quantity of Water drawn from Source (Gallons.)	Color.	Residue on Evaporation.	Ammonia, Free.	Ammonia, Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1889, ...	674,000	.00	-	.0010	.0022	2.07	.0372	.0000	-	-	-
1890, ...	777,000	.01	-	.0012	.0023	1.91	.0481	.0000	-	-	-
1891, ...	730,000	.00	10.85	.0008	.0015	1.79	.0668	.0000	-	4.9	-
1892, ...	775,000	.00	11.27	.0012	.0024	1.95	.0542	.0000	-	5.1	-
1893, ...	900,000	.00	11.50	.0022	.0018	2.04	.0447	.0000	.05	5.3	.0004
1894, ...	972,000	.01	11.02	.0026	.0018	1.94	.0262	.0000	.05	5.0	.0021
1895, ...	1,039,000	.01	10.82	.0031	.0022	1.74	.0204	.0000	.06	4.9	.0023
1896, ...	1,026,000	.01	10.49	.0033	.0031	1.56	.0242	.0000	.04	5.0	.0011
1897, ...	968,000	.01	10.06	.0041	.0032	1.36	.0202	.0000	.04	5.0	.0012
1898, ...	995,000	.02	10.15	.0041	.0026	1.27	.0252	.0000	.06	4.5	.0015
1899, ...	1,110,000	.01	9.51	.0044	.0025	1.19	.0258	.0000	.05	4.4	.0015
1900, ...	1,116,000	.00	9.32	.0055	.0029	1.20	.0169	.0000	.05	4.6	.0032
1901, ...	1,169,000	.00	9.52	.0053	.0033	1.17	.0209	.0000	.08	4.6	.0045
1902, ...	1,218,000	.01	9.82	.0062	.0029	1.15	.0200	.0000	.08	4.6	.0048
1903, ...	1,378,000	.00	9.81	.0067	.0029	1.18	.0204	.0000	.05	5.1	.0052
1904, ...	1,425,000	.00	9.95	.0071	.0033	1.17	.0180	.0000	.05	5.0	.0052
1905, ...	1,480,000	.01	9.66	.0073	.0033	1.16	.0115	.0000	.06	4.8	.0038


FREE AND ALB. AMM.
IRON.
DRAFT THOUSAND GALS. PER DAY.
BILLERICA
PARTS PER 100,000
.0030 .0600
.0020 .0400
.0010 .0200
110
90
70
ALB. AMM.
IRON
DRAFT
FREE AMM.
BROOKLINE
.0060 .0240
.0040 .0160
.0020 .0080
2250
2000
1750
1500
1250
DRAFT
ALB AMM.
FREE AMM.
IRON
HYDE PARK (NEPONSET)
.0150 .0675
.0100 .0450
.0050 .0225
800
700
600
500
400
300
DRAFT
FREE AMM.
ALB. AMM.
IRON
LOWELL
.0100 .0500
.0050 .0250
6000
5000
4000
3000
DRAFT
FREE AMM.
IRON
ALB. AMM.
1894
1896
1898
1900
1902
1904



FREE AND ALB. AMM.
IRON
DRAFT THOUSAND GALS. PER DAY.
MIDDLEBOROUGH
PARTS PER 100,000
.004 0.1000
.002 0.0500
250
225
200
ALB. AMM.
DRAFT
IRON
FREE AMM.
NEWTON
.004 0.0100
.002 0.0050
2100
1900
1700
1500
DRAFT
ALB. AMM.
IRON
FREE AMM.
WALTHAM
.004 0.0400
.002 0.0200
2250
2000
1750
1500
1250
DRAFT
ALB. AMM.
IRON
FREE AMM.
WOBURN
.006 0.0060
.004 0.0040
.002 0.0020
1400
1300
1200
1100
1000
900
FREE AMM.
IRON
DRAFT
ALB. AMM.
1894
1896
1898
1900
1902
1904

EXAMINATION OF RIVERS.

EXAMINATION OF RIVERS.

In the report for the year 1902, in the chapter entitled "Report upon the Examinations of the Outlets of Sewers and the Effect of Sewage Disposal in Massachusetts," the results of the investigation made in that year of the sources of pollution of streams in the State are presented in much detail, together with the results of analyses of the waters of these streams for a long series of years.

During the year 1905 the condition of the streams has not changed materially, and the examinations have been confined to a few of the more important rivers.

Chemical analyses of samples of water from the following streams have been made at frequent intervals during the year: —

Blackstone.	Nashua.	Stillwater.
Charles.	Neponset.	Sudbury.
Hoosick.	Quinepoxet.	Westfield.
Merrimack.	Saugus.	Westfield Little.

A summary of the various analyses showing the condition of the Blackstone and Merrimack rivers at several points is appended.

BLACKSTONE RIVER.

Blackstone River.

Chemical Examination of Water from Blackstone River. — Averages for Six Months, from June to November, 1887 to 1905, inclusive.

Blackstone River, between Mill Brook Channel and the Sewage Precipitation Works of the City of Worcester.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved.	Albuminoid Ammonia. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887, . .	0.91	–	–	.2686	.1741	–	–	1.35	.0160	–	–
" " 1888, . .	0.76	–	–	.2658	.1112	.0557	.0555	1.50	.0382	.0041	–
" " 1889, . .	0.86	–	–	.3980	.1430	.0772	.0658	1.32	.0177	.0026	–
" " 1890, . .	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891, . .	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
" " 1892, . .	0.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1
" " 1893, . .	0.40	16.98	4.55	.1480	.0588	.0240	.0348	1.01	.0115	.0015	6.3
" " 1894, . .	0.66	16.93	4.76	.0548	.0380	.0236	.0144	0.74	.0115	.0005	4.4
" " 1895, . .	0.49	14.17	4.50	.0613	.0414	.0243	.0171	0.92	.0163	.0006	3.4
" " 1896, . .	0.51	12.90	2.93	.0780	.0415	.0282	.0133	0.97	.0147	.0015	3.4
" " 1897, . .	0.85	26.45	7.68	.1130	.0674	.0362	.0312	0.89	.0090	.0024	4.2
" " 1898, . .	0.33	17.42	5.62	.0857	.0619	.0260	.0359	0.96	.0053	.0010	4.6
" " 1899, . .	0.14	34.38	10.60	.2583	.0788	.0390	.0398	–	–	.0004	14.3
" " 1900, . .	0.05	16.48	3.38	.1068	.0518	.0210	.0308	1.03	.0107	.0012	3.6
" " 1901, . .	0.23	31.03	11.68	.1410	.0548	.0309	.0239	–	–	.0023	13.8
" " 1902, . .	0.10	46.15	12.47	.2453	.0728	.0274	.0454	–	–	.0010	16.5
" " 1903, . .	0.18	24.06	6.80	.2836	.0750	.0472	.0278	–	–	.0027	8.4
" " 1904, . .	0.12	44.68	17.08	.1228	.0434	.0225	.0209	–	–	.0008	14.7
" " 1905, . .	0.21	50.36	19.49	.0952	.0492	.0203	.0289	–	–	.0003	29.3

Blackstone River, below Sewage Precipitation Works.

June-Nov., 1887, . .	0.91	–	–	.2686	.1741	–	–	1.35	.0160	–	–
" " 1888, . .	0.76	–	–	.2658	.1112	.0557	.0555	1.50	.0382	.0041	–
" " 1889, . .	0.86	–	–	.3980	.1430	.0772	.0658	1.32	.0177	.0026	–
" " 1890, . .	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891, . .	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892, . .	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
" " 1893, . .	0.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
" " 1894, . .	0.40	29.30	5.86	.6189	.1390	.1113	.0277	2.63	.0212	.0071	10.6
" " 1895, . .	0.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.3
" " 1896, . .	0.30	26.03	6.53	.2831	.0898	.0600	.0298	2.10	.0217	.0118	9.7
" " 1897, . .	0.73	25.98	4.97	.3650	.1122	.0782	.0340	1.61	.0207	.0063	6.9
" " 1898, . .	0.23	25.63	6.73	.3064	.0868	.0560	.0308	1.55	.0132	.0119	9.2
" " 1899, . .	0.14	44.02	9.67	.5251	.1707	.0912	.0795	3.26	.0108	.0068	16.1
" " 1900, . .	0.22	24.57	4.48	.4430	.1249	.0621	.0628	2.13	.0110	.0145	7.3
" " 1901, . .	0.09	31.12	6.90	.4580	.1293	.0772	.0521	3.42	.0090	.0058	10.8
" " 1902, . .	0.15	49.62	13.38	.7296	.1284	.0736	.0548	2.97	–	.0033	12.5
" " 1903, . .	0.39	31.08	9.48	.3880	.1080	.0545	.0535	–	–	.0062	10.4
" " 1904, . .	–	50.25	13.73	.6381	.1523	.0601	.0922	–	–	.0027	16.9
" " 1905, . .	0.19	59.84	17.97	.4936	.0985	.0597	.0388	–	–	.0008	29.3

BLACKSTONE RIVER.

CHEMICAL EXAMINATION OF WATER FROM BLACKSTONE RIVER, ETC. — *Concluded.*

Blackstone River, at Uxbridge.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved.	Albuminoid Ammonia. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June–Nov., 1887, . .	.39	–	–	.1129	.0271	–	–	0.79	.0360	–	–
" " 1888, . .	.38	6.42	1.52	.1155	.0288	.0222	.0066	0.68	.0310	.0007	–
" " 1889, . .	.32	–	–	.1133	.0296	.0192	.0104	0.66	.0333	.0009	–
" " 1890, . .	.26	8.86	2.12	.1629	.0231	.0174	.0057	0.79	.0259	.0005	2.9
" " 1891, . .	.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
" " 1892, . .	.13	9.36	1.88	.2840	.0227	.0162	.0065	0.99	.0313	.0007	3.1
" " 1893, . .	.24	11.74	2.37	.1985	.0207	.0140	.0067	1.20	.0623	.0050	4.2
" " 1894, . .	.35	13.07	2.03	.1456	.0243	.0183	.0060	1.57	.0673	.0050	4.9
" " 1895, . .	.56	12.95	2.69	.0906	.0258	.0182	.0076	1.34	.0631	.0065	4.7
" " 1896, . .	.33	12.68	2.67	.1129	.0257	.0221	.0036	1.38	.0477	.0091	5.0
" " 1897, . .	.48	11.60	2.47	.1029	.0280	.0215	.0065	1.32	.0652	.0051	4.3
" " 1898, . .	.49	10.59	2.78	.0801	.0264	.0219	.0045	1.00	.0470	.0076	3.8
" " 1899, . .	18	18.34	3.11	.2490	.0359	.0310	.0049	2.17	.0510	.0141	7.4
" " 1900, . .	.19	13.42	2.04	.2260	.0347	.0257	.0090	1.76	.0558	.0060	5.0
" " 1901, . .	.22	13.91	2.67	.3159	.0285	.0240	.0045	1.50	.0195	.0035	5.0
" " 1902, . .	.15	14.17	2.56	.3462	.0270	.0218	.0052	1.95	.0210	.0018	4.9
" " 1903, . .	.30	13.16	2.52	.3030	.0262	.0215	.0047	1.74	.0210	.0024	4.4
" " 1904, . .	.20	13.78	2.74	.2399	.0282	.0214	.0068	2.12	.0408	.0022	4.6
" " 1905, . .	.21	16.34	2.55	.3928	.0246	.0203	.0043	2.65	.0175	.0025	5.0

Blackstone River, at Millville.

Months.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved.	Albuminoid Ammonia. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June–Nov., 1887, . .	.31	–	–	.0468	.0220	–	–	0.51	.0210	–	–
" " 1888, . .	.41	5.22	1.40	.0467	.0296	.0233	.0063	0.50	.0278	.0004	–
" " 1889, . .	.38	–	–	.0499	.0273	.0213	.0060	0.45	.0167	.0003	–
" " 1890, . .	.26	6.71	2.24	.0736	.0196	.0152	.0044	0.53	.0229	.0003	2.3
" " 1891, . .	.24	7.48	2.35	.1105	.0384	.0234	.0150	0.72	.0308	.0006	2.2
" " 1892, . .	.37	6.70	1.62	.1143	.0294	.0210	.0084	0.63	.0217	.0002	2.0
" " 1893, . .	.23	7.43	1.73	.0677	.0119	.0087	.0032	0.77	.0385	.0011	2.6
" " 1894, . .	.47	8.42	2.16	.0510	.0172	.0139	.0033	0.89	.0273	.0012	2.8
" " 1895, . .	.51	8.67	2.55	.0356	.0233	.0180	.0053	0.90	.0383	.0024	3.2
" " 1896, . .	.35	8.53	1.69	.0484	.0237	.0180	.0057	0.97	.0413	.0027	3.3
" " 1897, . .	.45	7.66	1.98	.0509	.0258	.0210	.0048	0.92	.0445	.0019	3.1
" " 1898, . .	.51	7.12	2.17	.0325	.0240	.0193	.0047	0.63	.0240	.0023	2.5
" " 1899, . .	.20	12.50	2.44	.1310	.0301	.0247	.0054	1.31	.0310	.0049	4.6
" " 1900, . .	.29	9.33	1.82	.1168	.0254	.0219	.0035	1.15	.0417	.0039	3.4
" " 1901, . .	.31	8.62	2.13	.1420	.0288	.0227	.0061	0.87	.0155	.0006	3.1
" " 1902, . .	.28	9.43	2.24	.1623	.0284	.0238	.0046	1.20	.0195	.0010	2.8
" " 1903, . .	.33	8.46	1.85	.1397	.0233	.0189	.0044	1.10	.0192	.0010	2.9
" " 1904, . .	.29	8.71	2.06	.1079	.0235	.0201	.0034	1.26	.0337	.0009	2.9
" " 1905, . .	.28	10.76	2.03	.1956	.0311	.0222	.0089	1.67	.0207	.0008	2.9

NOTE. — The sewage purification works of the city of Worcester were put in operation in 1890, since which time a portion of the sewage of the city has been treated. The works were enlarged in 1893, and since that time practically all of the dry-weather flow of sewage has been treated.

Merrimack River.

Table comparing the Analyses above Lowell with those above Lawrence, 1905.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Mean of analyses above Lowell, .	.37	4.26	1.84	.0098	.0204	.0157	.0047	.24	.0047	.0002	1.1
Mean of analyses above Lawrence, .	.41	4.70	1.93	.0145	.0246	.0181	.0065	.34	.0049	.0004	1.2
Increase, ...	.04	0.44	0.09	.0047	.0042	.0024	.0018	.10	.0002	.0002	0.1

In order to compare these results with similar ones obtained in previous years, another table is presented, which shows the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years.

Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.

[Parts per 100,000.]

Date.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Increase, 1887–1889, .	0.01	0.23	0.09	.0007	.0027	.0017	.0010	.026	.0003[1]	.0000	–
Increase, 1890, . .	0.05	0.62	0.22[1]	.0016	.0023	.0017	.0006	.028	.0020[1]	.0000	0.2
Increase, 1891, . .	0.02[1]	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030[1]	.0000	0.1
Increase, 1892, . .	0.06	0.48	0.12	.0019	.0037	.0037	.0000	.039	.0013[1]	.0000	0.0
Increase, 1893, . .	0.09	0.47	0.30	.0031	.0032	.0021	.0011	.035	.0002[1]	.0001	0.0
Increase, 1894, . .	0.02	0.15	0.04	.0028	.0032	.0032	.0000	.049	.0000	.0000	0.1
Increase, 1895, . .	0.11	0.52	0.33	.0022	.0063	.0046	.0017	.063	.0005	.0001	0.1
Increase, 1896, . .	0.02	0.51	0.24	.0034	.0053	.0047	.0006	.070	.0017	.0002	0.2
Increase, 1897, . .	0.06	0.30	0.08	.0019	.0051	.0033	.0018	.050	.0000	.0000	0.1
Increase, 1898, . .	0.03	0.37	0.07	.0024	.0039	.0019	.0020	.044	.0010	.0002	0.1
Increase, 1899, . .	0.02	0.39	0.07	.0038	.0045	.0023	.0022	.059	.0004[1]	.0001	0.1
Increase, 1900, . .	0.03	0.41	0.11	.0037	.0027	.0026	.0001	.055	.0011	.0000	0.0
Increase, 1901, . .	0.03	0.27	0.03	.0032	.0044	.0023	.0021	.053	.0020	.0003	0.3
Increase, 1902, . .	0.03	0.52	0.20	.0032	.0063	.0027	.0036	.060	.0000	.0001	0.1
Increase, 1903, . .	0.04	0.56	0.18	.0043	.0065	.0045	.0020	.072	.0014	.0002	0.2
Increase, 1904, . .	0.02	0.31	0.06	.0092	.0047	.0026	.0021	.100	.0004[1]	.0001	0.1
Increase, 1905, . .	0.04	0.44	0.09	.0047	.0042	.0024	.0018	.102	.0002	.0002	0.1

The average flow of the river at Lawrence, for twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931, 5,434, 8,126, 5,459, 11,634, 5,886, 8,230, 9,402, 7,406, 7,389, 8,524, 9,160, 9,674, 7,410 and 7,451 cubic feet per second.

[1] Decrease.

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

WATER SUPPLY STATISTICS.

During the year 1905 water supplies were introduced into the towns of Holden (population, 2,640) and Hadley (population, 1,895). The works in Holden are owned by the town, and in Hadley by the Hadley Water Supply District.

At the present time all of the 33 cities in Massachusetts and 149 of the 321 towns are provided with public water supplies. The following table gives a classification by population of the cities and towns having and not having public water supplies: —

Population (1905).	Number of Places of Given Population having Public Water Supplies.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	-	-	36	12,513
500–999,	4	3,755	50	36,782
1,000–1,499,	13	15,774	37	46,117
1,500–1,999,	13	23,445	22	38,534
2,000–2,499,	13	28,293	15	32,174
2,500–2,999,	12	32,082	3	8,444
3,000–3,499,	8	25,943	2	6,441
3,500–3,999,	5	18,931	3	11,394
Above 4,000,	114	2,644,267	4	18,791
Totals,	182	2,792,490	172	211,190

All of the towns except Blackstone having a population in excess of 5,000 are supplied with water, and there are only 9 towns in the State having a population in excess of 3,000 which are not provided with public water supplies. These towns are as follows: —

Town.	Population in 1905.	Town.	Population in 1905.
Blackstone,	5,786	Dartmouth,	3,793
Tewksbury,	4,415	Templeton,	3,783
Barnstable,	4,336	Pepperell,	3,268
Chelmsford,	4,254	Sutton,	3,173
Dudley,	3,818		

During the year 1905 the works at Amesbury, Athol, Revere and Tisbury, which were formerly owned by water companies, were taken by the town; and the towns of Framingham (population, 11,548) and Winthrop (population, 7,034) have voted to take the works of the water companies in those places.

At the present time in all of the cities and 102 of the towns the works are owned either by the municipality or by a fire or water-supply district, and in 47 towns the works are owned by private companies. The following table gives a classification by population of the cities and towns which own their water works and those which are supplied with water by private companies: —

Population (1905).	Number of Places of Given Population owning Water Works.	Total Population of Places in Preceding Column.	Number of Places of Given Population supplied with Water by Private Companies.	Total Population of Places in Preceding Column.
Under 1,000,	2	1,886	2	1,869
1,000-1,999,	18	28,310	8	10,909
2,000-2,999,	13	31,614	12	28,761
3,000-3,999,	5	17,022	8	27,852
4,000-4,999,	12	52,834	5	22,410
5,000-5,999,	11	60,243	3	15,609
6,000-6,999,	12	77,889	1	6,754
7,000-7,999,	6	43,474	4	29,963
Above 8,000,	56	2,285,928	4	49,163
Totals,	135	2,599,200	47	193,290

From the totals given in the above tables it will be seen that the population of those towns supplied with water by private companies is only 6.9 per cent. of the total population in all the cities and towns supplied with water, and that there are at the present time only 4 towns having a population above 8,000 which are supplied by private companies. These are Framingham, Hyde Park, Milford and Southbridge.

Records of the consumption of water are kept in nearly all of the cities and towns where water is pumped, and in several cities and towns Venturi meters are used to measure the quantity supplied. A summary of these statistics for the year 1905 is given in the following table. The daily consumption of water per inhabitant has been obtained by dividing the average daily consumption by the population as given by the census. The quantity obtained in this manner varies somewhat from the actual consumption per person using the water, as in many cities and towns there is a considerable number of persons who do not use the public water supply, while in some of the towns used as summer resorts the population using the water during the summer months is much greater than the population shown by the census. With a few exceptions, however, the error is not large.

Statistics relating to the Consumption of Water in Various Cities and Towns.

City or Town.	Population in **1905.**	Average Daily Consumption (Gallons), **1905.**	Daily Consumption per Inhabitant (Gallons), **1905.**
Metropolitan Water District.[1]	900,104	116,620,000	129
Arlington, . .	9,668	788,000	81
Belmont, . .	4,360	266,000	61
Boston, . .	595,380	89,744,000	151
Chelsea, . .	37,289	4,091,000	110
Everett, . .	29,111	2,592,000	89
Lexington, .	4,530	299,000	66
Malden, . .	38,037	2,019,000	53
Medford, . .	19,686	1,922,000	97
Melrose, . .	14,295	1,601,000	112
Milton, . .	7,054	305,000	43
Nahant, . .	922	137,000	148
Quincy, . .	28,076	3,050,000	109
Revere, . .	12,659	1,007,000	78
Somerville, .	69,272	6,161,000	89
Stoneham, . .	6,332	514,000	81
Swampscott, .	5,141	535,000	104
Watertown, .	11,258	791,000	70
Winthrop, . .	7,034	798,000	113
Abington and Rockland.	11,368	464,000	41
Amesbury, . . .	8,840	405,000	46
Andover, ...	6,632	444,000	67
Attleborough, . .	12,702	602,000	47
Avon, ...	1,901	76,000	40
Ayer, ...	2,386	126,000	53
Beverly, ...	15,223	1,321,000	87
Billerica, ...	2,843	80,000	28
Braintree, ...	6,879	600,000	87
Bridgewater and East Bridgewater.	9,923	204,000	21
Brockton, ...	47,794	1,802,000	38
Brookline, . . .	23,436	2,227,000	95
Cambridge, . . .	97,434	8,973,000	92
Canton, ...	4,702	296,000	63
Clinton, ...	13,105	542,000	41
Danvers and Middleton.	10,131	820,000	81
Dedham, ...	7,774	1,046,000	135
Easton, ...	4,909	117,000	24
Fairhaven, . . .	4,235	333,000	79
Fall River, . . .	105,762	4,407,000	42
Falmouth, . . .	3,241	238,000	73
Foxborough, . .	3,364	213,000	63
Framingham, . .	11,548	569,000	49
Franklin, ...	5,244	233,000	44
Gardner, ...	12,012	958,000	80
Gloucester, . . .	26,011	1,374,000	53
Groton, ...	2,253	64,000	28
Holliston, ...	2,663	28,000	11
Holyoke, ...	49,934	5,996,000	120
Hyde Park, . . .	14,510	1,121,000	77
Ipswich, ...	5,205	138,000	26
Lancaster, . . .	2,406	78,000	33
Lawrence, . . .	70,050	2,978,000	43
Lincoln, ...	1,122	151,000	135
Lowell, ...	94,889	5,467,000	58
Lynn and Saugus, .	83,295	4,927,000	59
Manchester, . . .	2,618	246,000	94
Mansfield, . . .	4,245	206,000	49
Marblehead, . . .	7,209	562,000	78
Marlborough, . .	14,073	579,000	41
Maynard, ...	5,811	261,000	45
Merrimac, . . .	1,884	52,000	28
Methuen, ...	8,676	372,000	43
Middleborough, .	6,888	260,000	38
Milford and Hopedale.	14,153	926,000	65
Millbury, ...	4,631	221,000	48
Montague, . . .	7,015	571,000	81
Nantucket, . . .	2,930	165,000	56
Natick, ...	9,609	534,000	56

[1] The figures given for the cities and towns in the Metropolitan Water District are taken from the report of the Metropolitan Water and Sewerage Board.

Statistics relating to the Consumption of Water in Various Cities and Towns — Concluded.

City or Town.	Population in 1905.	Average Daily Consumption (Gallons), 1905.	Daily Consumption per Inhabitant (Gallons), 1905.	City or Town.	Population in 1905.	Average Daily Consumption (Gallons), 1905.	Daily Consumption per Inhabitant (Gallons), 1905.
Needham,	4,284	284,000	66	Sharon,	2,085	91,000	44
New Bedford,	74,362	7,087,000	95	Shirley,	1,692	22,000	13
Newburyport,	14,675	743,000	51	Stoughton,	5,959	379,000	64
Newton,	36,827	2,151,000	58	Taunton,	30,967	1,910,000	62
North Andover,	4,614	198,000	43	Tisbury,	1,120	70,000	63
North Attleborough,	7,878	316,000	40	Wakefield,	10,268	747,000	73
North Brookfield,	2,617	125,000	48	Walpole,	4,003	345,000	86
Norwood,	6,731	433,000	64	Waltham,	26,282	2,070,000	79
Orange,	5,578	150,000	27	Ware,	8,594	351,000	41
Peabody,	13,098	1,747,000	133	Wareham,	3,660	35,000	10
Provincetown,	4,362	123,000	28	Webster,	10,018	336,000	34
Randolph and Holbrook.	6,543	258,000	39	Wellesley,	6,189	289,000	47
Reading,	5,682	158,000	28	Weston,	2,091	66,000	31
Rockport,	4,447	359,000	81	Whitman,	6,521	161,000	25
Rutland,	1,713	88,000	51	Winchendon,	5,933	108,000	18
Salem,	37,627	3,336,000	89	Woburn,	14,402	1,490,000	103
Scituate,	2,597	95,000	37	Worcester,	128,135	9,581,000	75

Rainfall.

The average rainfall in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.34 inches. The average rainfall for the year 1905 in these places was 37.60 inches, making a deficiency of 7.74 inches, the greatest deficiency that has occurred since 1894. There was an excess of rainfall only in the months of January, June and September, and a deficiency during the remaining nine months. The greatest deficiency occurred in May and October, when the rainfall was 1.41 and 1.64 inches respectively.

The following table gives the normal rainfall in the State for each month, as deduced from observations at various places for a long period of years, together with the average rainfall at those places for each month during 1905, and the departures from the normal: —

Month.	Normal Rainfall (Inches).	Rainfall 1905 (Inches).	Excess or Deficiency 1905 (Inches).	Month.	Normal Rainfall (Inches).	Rainfall 1905 (Inches).	Excess or Deficiency 1905 (Inches).
January, . .	3.91	4.33	+0.42	August, . .	4.26	4.01	—0.25
February, . .	3.73	1.76	—1.97	September, .	3.46	6.57	+3.11
March, . .	4.13	3.11	—1.02	October, . .	3.95	1.64	—2.31
April, . . .	3.58	2.45	—1.13	November, . .	3.95	2.43	—1.52
May, . . .	3.62	1.41	—2.21	December, . .	3.68	2.92	—0.76
June, . . .	3.31	4.71	+1.40	Total, . .	45.34	37.60	—7.74
July, . . .	3.76	2.26	—1.50				

Flow of Streams.

The flow of streams for the year 1905, as indicated by the records of the flow of the Sudbury River, was less than normal. The flow was in excess of the normal in only two months during the year. The greatest excess occurred during the month of September and the greatest deficiency during the month of February. In order to show the relation between the flow of the Sudbury River during each month of 1905 and the normal flow of that stream as deduced from observations during thirty-one years, from 1875 to 1905, inclusive, the following table has been prepared from data obtained from the Metropolitan Water and Sewerage Board. The drainage area of the Sudbury River above the point of measurement is 75.2 square miles.

Month.	Normal Flow.		Actual Flow for 1905.		Excess or Deficiency.	
	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.
January, ...	1.892	1.223	2.182	1.410	+0.290	+0.187
February, ...	2.803	1.812	0.510	0.330	—2.293	—1.482
March, ...	4.596	2.971	3.864	2.497	—0.732	—0.474
April, ...	3.249	2.100	2.543	1.643	—0.706	—0.457
May, ...	1.724	1.114	0.460	0.297	—1.264	—0.817
June, ...	0.805	0.520	0.723	0.467	—0.082	—0.053
July, ...	0.298	0.193	0.275	0.177	—0.023	—0.016
August, ...	0.441	0.285	0.177	0.114	—0.264	—0.171
September, ...	0.419	0.271	1.928	1.246	+1.509	+0.975
October, ...	0.766	0.495	0.245	0.158	—0.521	—0.337
November, ...	1.314	0.849	0.431	0.279	—0.883	—0.570
December, ...	1.665	1.076	1.373	0.887	—0.292	—0.189
Year, ...	1.658	1.072	1.230	0.795	—0.428	—0.277

The next table shows the weekly fluctuations during 1905 in the flow of three streams which were carefully measured, namely, the Sudbury, south branch of the Nashua and the Merrimack rivers. The flow of these streams, particularly the Sudbury and the south branch of the Nashua, serves to indicate the flow of other streams in eastern Massachusetts. The flow of the Merrimack River is affected to some extent by the diversion of water from two of its branches for the water supply of the Metropolitan Water District. The quantity diverted in 1905 amounted to about 180 cubic feet per second, which would reduce the figures given for the flow per square mile of water-shed about .039 of a cubic foot per second. The water-shed of the Sudbury River is 75.2 square miles, of the Nashua 119 square miles, and of the Merrimack 4,664 square miles.

Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.			Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.		
	Sudbury River.	South Branch Nashua River.	Merrimack River.		Sudbury River.	South Branch Nashua River.	Merrimack River.
1905.				**1905.**			
Jan. 1,	1.589	1.477	0.414	July 9,	0.074	0.440	0.811
8,	4.551	3.675	0.667	16,	0.334	1.008	0.548
15,	2.717	2.577	1.332	23,	0.098	0.338	0.493
22,	1.290	1.128	0.834	30,	0.194	0.461	0.423
29,	0.392	0.843	0.610	Aug. 6,	0.919	0.680	0.679
Feb. 5,	0.470	0.711	0.548	13,	0.149	0.458	0.484
12,	0.889	0.801	0.503	20,	0.161	0.593	0.675
19,	0.366	0.655	0.482	27,	0.028	0.372	0.497
26,	0.310	0.640	0.468	Sept. 3,	1.086	1.751	0.538
Mar. 5,	0.564	0.707	0.461	10,	5.797	4.071	2.462
12,	2.627	1.924	0.559	17,	0.840	1.382	1.237
19,	3.533	4.029	0.848	24,	0.655	0.842	2.216
26,	6.012	7.152	2.163	Oct. 1,	0.261	0.352	0.938
Apr. 2,	5.688	8.302	8.679	8,	—0.064	0.419	0.670
9,	4.010	4.058	4.896	15,	0.194	0.608	0.690
16,	3.157	2.859	3.616	22,	0.638	0.757	0.722
23,	1.846	1.471	2.116	29,	0.326	0.560	0.699
30,	0.615	1.044	1.728	Nov. 5,	0.373	0.606	0.602
May 7,	0.911	0.860	1.349	12,	0.450	0.837	1.006
14,	0.523	0.694	1.180	19,	0.403	0.481	0.748
21,	0.780	0.791	1.235	26,	0.170	0.535	0.620
28,	0.745	0.517	0.874	Dec. 3,	0.998	1.330	0.759
June 4,	—0.711	0.352	0.617	10,	1.927	1.608	2.009
11,	0.616	0.705	0.676	17,	0.648	0.910	0.860
18,	0.887	0.902	0.734	24,	1.586	2.080	0.955
25,	1.913	1.395	1.204	31,	1.966	1.684	1.185
July 2,	0.153	0.549	1.111				

The following table gives the rainfall upon the Sudbury River water-shed and the yield of the stream expressed in inches in depth on the water-shed (inches of rainfall collected), for the year 1905, together with the average of the records for thirty-one years, from 1875 to 1905, inclusive: —

Month.	1905.			Mean for 31 Years. 1875-1905.		
	Rainfall.	Rainfall collected.	Per Cent. collected.	Rainfall.	Rainfall collected.	Per Cent. collected.
January,	5.26	2.516	47.8	4.24	2.182	51.5
February,	2.20	0.531	24.2	4.27	2.942	68.9
March,	3.15	4.456	141.5	4.55	5.299	116.6
April,	2.72	2.837	104.2	3.58	3.626	101.3
May,	1.31	0.530	40.4	3.28	1.987	60.6
June,	5.00	0.806	16.1	3.15	0.898	28.5
July,	5.47	0.316	5.8	3.73	0.344	9.2
August,	2.70	0.204	7.6	4.01	0.509	12.7
September,	6.88	2.152	31.3	3.43	0.467	13.6
October,	1.54	0.282	18.3	4.14	0.883	21.3
November,	2.07	0.481	23.3	3.89	1.466	37.6
December,	4.01	1.583	39.5	3.82	1.920	50.2
Year,	42.31	16.694	39.5	46.09	22.523	48.9

The Sudbury River records are particularly valuable as a basis for estimating the yield of other water-sheds in Massachusetts, both on account of the accuracy with which the measurements have been made and the absence of abnormal conditions which would unfavorably affect the results.

The following table gives the records of the yield of this water-shed for each year for the past thirty-one years, the flow from the water-shed being expressed in gallons per day per square mile of water-shed, in order to render the table more convenient for use in estimating the probable yield of water-sheds used as sources of water supply: —

Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile.[1]

Month.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000	1,241,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000	2,839,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000	867,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000
June,	870,000	222,000	597,000	506,000	413,000	176,000	1,338,000	529,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000	86,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000	55,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000	306,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000	299,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000	210,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000	314,000
Av. for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000	862,000
Av. for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000

Month.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
January,	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000	2,782,000	1,254,000
February,	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000	1,951,000	1,195,000	1,529,000
March,	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,237,000	1,339,000	3,643,000
April,	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000	1,410,000	1,875,000
May,	938,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000	880,000	1,366,000
June,	300,000	417,000	426,000	203,000	414,000	422,000	653,000	568,000
July,	115,000	224,000	62,000	115,000	114,000	117,000	633,000	108,000
August,	78,000	257,000	240,000	94,000	214,000	380,000	1,432,000	132,000
September,	91,000	44,000	121,000	118,000	111,000	1,155,000	824,000	458,000
October,	186,000	83,000	336,000	146,000	190,000	1,999,000	1,230,000	2,272,000
November,	205,000	175,000	1,178,000	673,000	368,000	2,758,000	1,941,000	1,215,000
December,	193,000	925,000	1,174,000	1,020,000	643,000	3,043,000	2,241,000	997,000
Av. for whole year,	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000	1,383,000	1,285,000
Av. for driest six months,	145,000	200,000	391,000	223,000	234,000	953,000	944,000	747,000

[1] The area of the Sudbury River water-shed used in making up these records included water surfaces amounting to about 2 per cent. of the whole area, from 1875 to 1878 inclusive, subsequently increasing by the construction of storage reservoirs to about 3 per cent. in 1879, to 3.5 per cent. in 1885, to 4 per cent. in 1894 and to 6.5 per cent. in 1898. The water-shed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile — Concluded.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January,	3,018,000	1,870,000	433,000	693,000	1,034,000	1,084,000	845,000	1,638,000
February,	3,486,000	943,000	1,542,000	991,000	541,000	2,676,000	1,067,000	3,022,000
March,	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000	2,565,000	2,604,000
April,	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,494,000	1,515,000	1,829,000
May,	582,000	1,259,000	2,883,000	840,000	636,000	360,000	915,000	1,246,000
June,	414,000	428,000	440,000	419,000	174,000	399,000	962,000	530,000
July,	149,000	214,000	158,000	161,000	231,000	95,000	658,000	231,000
August,	163,000	280,000	181,000	209,000	229,000	57,000	591,000	1,107,000
September,	203,000	229,000	108,000	150,000	89,000	388,000	182,000	369,000
October,	210,000	126,000	221,000	374,000	1,379,000	592,000	94,000	1,160,000
November,	305,000	697,000	319,000	836,000	2,777,000	659,000	909,000	1,986,000
December,	544,000	485,000	797,000	716,000	1,782,000	657,000	1,584,000	1,799,000
Av. for whole year,	1,315,000	781,000	1,037,000	770,000	1,152,000	1,019,000	991,000	1,450,000
Av. for driest six months,	239,000	327,000	237,000	356,000	460,000	314,000	564,000	777,000

Month.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	Mean for 31 Years, 1875 to 1905, inclusive.
January,	2,288,000	794,000	437,000	1,763,000	1,736,000	477,000	1,410,000	1,223,000
February,	1,381,000	3,800,000	300,000	1,674,000	2,279,000	882,000	330,000	1,812,000
March,	4,205,000	3,654,000	2,755,000	4,199,000	3,454,000	2,999,000	2,497,000	2,971,000
April,	2,521,000	1,350,000	4,204,000	1,885,000	2,261,000	3,294,000	1,643,000	2,100,000
May,	511,000	1,312,000	2,954,000	743,000	351,000	1,745,000	297,000	1,114,000
June,	66,000	316,000	753,000	303,000	1,987,000	419,000	467,000	520,000
July,	19,000	—18,000	306,000	66,000	445,000	62,000	177,000	193,000
August,	—35,000	—34,000	424,000	135,000	307,000	170,000	114,000	285,000
September,	94,000	65,000	305,000	178,000	130,000	397,000	1,246,000	271,000
October,	115,000	186,000	412,000	506,000	492,000	191,000	158,000	495,000
November,	304,000	663,000	474,000	444,000	363,000	289,000	279,000	849,000
December,	220,000	1,096,000	2,695,000	1,779,000	582,000	269,000	887,000	1,076,000
Av. for whole year,	973,000	1,082,000	1,342,000	1,140,000	1,190,000	931,000	795,000	1,072,000
Av. for driest six months,	93,000	194,000	445,000	271,000	386,000	228,000	224,000	434,000

MATERIALS USED FOR SERVICE PIPES IN MASSACHUSETTS.

MATERIALS USED FOR SERVICE PIPES IN MASSACHUSETTS.

Many instances have been given in previous reports of cases of lead poisoning resulting from the use of water drawn through lead service pipes. The results of investigations show that the principal agent in the action of water upon lead pipe is carbonic acid, which is present in varying quantities in the different waters. Ground waters have been found to contain as a rule a greater quantity of carbonic acid than surface waters, and the greatest number of cases of lead poisoning thus far investigated has occurred in cities and towns supplied with ground waters, notably in Fairhaven, Kingston, Lowell, Milford and Milton. Surface waters, after standing for a considerable time in lead pipes, have often been found to contain quantities of lead in excess of the minimum amount believed to have caused injury to health, which is approximately .05 of a part in 100,000 parts of water; but, as a rule, the quantities found in surface waters have been less than this minimum.

That there is danger, however, in the use of lead service pipes when used with surface waters has been shown by the occurrence of cases of lead poisoning during the past year in the town of Norwood, which is supplied with water from a pond. An examination made in 1898 had shown that the water drawn from service pipes in various parts of the town did not contain excessive quantities of lead; but the results of an examination in January, 1905, showed its presence in quantities much greater than those which had been found in the water seven years before, and much greater than those which have been known to cause lead poisoning. Additional examinations later in the year confirmed the results of the January analyses, showing that lead was being dissolved in large quantities from the lead service pipes in Norwood as the water was drawn in ordinary use; and it was evident that a continuance of this condition would result in very serious injury to the health of those using the water. The matter has been brought to the attention of the authorities of the town of Norwood, and the further use of lead for new service pipes has been discontinued and provision made for removing those now in use.

Notwithstanding the danger from the use of lead pipes for distributing water, many cities and towns continue to use this metal, though pipes of other material, not likely to injure health, have been in use for many years.

In order to learn to what extent lead is used for service pipes as compared with other materials in this State, and the experience in the use of the various kinds of service pipes, information has been collected from the water departments of the cities and towns, the results of which are presented herewith.

Number of Service Pipes of Different Materials in Use in Cities and Towns of Massachusetts.

City or Town.	Wrought Iron.	Galvanized Iron.	Cement lined.	Lead.	Lead lined.	Tin lined.	Total.	Material now used for New Services.
Abington, . . .	-	12	1,000	-	-	-	1,012	Cement lined.
Agawam, . . .	-	55	-	-	-	-	55	Galvanized iron.
Amesbury, . .	1,300	-	-	-	-	-	1,300	Galvanized iron.
Amherst, . . .	25	550	-	25	-	-	600	Galvanized iron.
Andover, . . .	14	-	642	6	316	-	981	Lead lined.
Arlington, . .	-	-	1,880	-	-	-	1,880	Cement lined.
Ashburnham, . .	-	3	-	72	-	-	75	Lead and galvanized iron.
Ashfield, . . .	-	17	-	-	-	-	17	Galvanized iron.
Athol, . . .	300	710	-	-	-	-	1,010	Galvanized iron.
Attleborough, . .	-	664	986	-	-	1	1,651	Cement lined.
Avon, . . .	-	3	361	-	-	-	364	Cement lined.
Ayer, . . .	About half.	About half.	-	1	-	-	471	Galvanized iron.
Barre, . . .	-	-	110	-	-	-	110	Cement lined.
Belmont, . . .	-	75	598	-	-	-	673	Galvanized iron.
Beverly, . . .	-	3,376	2	-	172	-	3,550	Galvanized iron.
Billerica, . . .	-	-	268	-	-	-	268	Cement lined.
Boston, . . .	-	-	-	Nearly all.	-	-	90,560	Lead.
Braintree, . . .	-	About 800.	-	About 600.	-	6	1,400	Lead and tin lined.
Bridgewater and East Bridgewater.	Unknown.	Unknown.	-	Very few.	Very few.	Very few.	870	Galvanized iron.
Brockton, . . .	886	-	5,161	-	17	-	6,097	Cement lined.
Brookfield, . .	-	82	-	10	-	-	92	Lead.
Brookline, . .	-	681	3,410	-	-	-	4,091	Cement lined.
Cambridge, . .	-	14,803	-	-	-	-	14,803	Galvanized iron.
Canton, . . .	25	50	795	-	-	-	870	Cement lined.
Chelsea, . . .	-	-	-	6,357	-	-	6,357	Lead.
Cheshire, . . .	9	150	-	1	-	-	160	Galvanized iron.
Chester, . . .	-	190	-	-	-	-	190	Galvanized iron.
Chicopee, . . .	400	-	-	1,653	-	-	2,053	Lead.
Clinton, . . .	-	-	1,815	-	-	-	1,815	Cement lined.
Cohasset, . . .	-	415	70	5	-	-	490	Galvanized iron.
Colrain, . . .	-	6	-	-	-	-	6	Galvanized iron.

Number of Service Pipes of Different Materials in Use, etc. — Continued.

City or Town.	Wrought Iron.	Galvanized Iron.	Cement lined.	Lead.	Lead lined.	Tin lined.	Total.	Material now used for New Services.
Concord,	–	–	–	–	–	–	–	Lead.
Cottage City,	–	650	–	2	–	–	890	– –
Dalton,	–	700	–	–	–	–	700	Galvanized iron.
Danvers,	–	–	1,771	–	–	–	1,771	Cement lined.
Dedham,	200	100	1,246	30	–	3	1,579	Cement lined.
Deerfield,	–	100	–	–	–	–	100	Galvanized iron.
Dracut,	–	121	–	–	–	–	121	Galvanized iron.
Easthampton,	100	700	–	–	–	–	800	Galvanized iron.
Easton,	200	–	–	–	300	–	500	Lead lined.
Everett,	–	–	–	4,853	–	–	4,853	Lead.
Fairhaven,	–	50	–	–	–	600	650	Tin lined.
Fall River,	–	–	–	7,667	–	–	7,667	Lead.
Falmouth,	–	All.	–	–	–	–	–	Galvanized iron.
Fitchburg,	–	–	4,766	–	–	–	4,766	Cement lined.
Foxborough,	Very few.	Very few.	Nearly all.	–	–	–	528	Cement lined.
Framingham,	–	–	–	–	–	–	1,200	Lead and galvanized iron.
Franklin,	200	226	276	8	–	–	710	Cement lined and galvanized iron.
Gardner,	–	–	1,383	–	–	–	1,383	Cement lined.
Gill,	62	–	–	–	–	–	62	Wrought iron.
Gloucester,	100	500	3,170	–	6	–	3,776	Galvanized iron.
Grafton,	331	–	–	4	–	–	335	Wrought iron and galvanized iron.
Great Barrington,	–	827	–	–	–	–	827	Galvanized iron.
Greenfield,	Few.	Nearly all.	2	–	–	–	1,735	Galvanized iron.
Groton,	–	206	3	–	–	–	209	Galvanized iron.
Hardwick,	–	–	2	3	–	–	5	Cement lined.
Hatfield,	–	286	–	–	–	–	286	Galvanized iron.
Haverhill,	–	97	–	5,600	1	–	5,698	Lead.
Hingham and Hull,	–	Unknown.	Unknown.	Very few.	1	–	2,200	Galvanized iron.
Hinsdale,	–	190	–	–	–	–	190	Galvanized iron.
Holbrook,	–	1	524	–	–	–	525	Cement lined.
Holden,	–	–	128	–	–	–	128	Cement lined.
Holliston,	35	90	–	25	–	–	150	Galvanized iron.
Holyoke,	–	–	–	–	–	–	3,760	Tin lined.
Hopkinton,	About half.	About half.	–	12	1	–	398	Galvanized iron.
Hudson,	–	–	987	–	–	–	987	Cement lined.
Huntington,	1	153	–	–	–	–	154	Galvanized iron.

Number of Service Pipes of Different Materials in Use, etc. — Continued.

City or Town.	Wrought Iron.	Galvanized Iron.	Cement lined.	Lead.	Lead lined.	Tin lined.	Total.	Material now used for New Services.
Hyde Park,	-	6	2,428	-	-	-	2,454	Cement lined.
Ipswich,	-	5	-	728	-	-	733	Lead.
Kingston,	4	-	-	250	-	150	404	Tin lined.
Lancaster,	-	-	300	64	-	-	364	Cement lined.
Lawrence,	136	1,694	-	About 3,722.	About 902.	About 11.	6,483	Lead and lead lined.
Lee,	-	460	-	-	-	-	460	- -
Lenox,	-	217	-	-	-	-	217	Galvanized iron.
Leominster,	12	12	2,376	-	-	-	2,459	Cement lined and cast iron.
Lincoln,	-	-	-	-	-	-	188	Galvanized iron.
Longmeadow,	-	All.	-	-	-	-	-	- -
Lowell,	-	-	296	-	-	-	11,287	Tin lined.
Lynn,	-	Very few.	11,647	-	About 1,600.	-	13,247	Lead lined.
Malden,	Very few.	Very few.	-	Nearly all.	-	-	7,357	Lead.
Manchester,	-	15	750	-	-	2	767	Cement lined and galvanized iron.
Mansfield,	-	455	-	5	-	-	745	Galvanized iron.
Marblehead,	-	1,872	-	-	-	-	1,872	Galvanized iron.
Marlborough,	-	50	1,621	400	200	-	2,271	Lead and galvanized iron.
Marshfield,	-	300	-	-	-	-	300	Galvanized iron.
Maynard,	-	About 20.	600	1	100	-	720	Cement lined and galvanized iron.
Medfield,	About half.	About half.	-	1	-	-	100	Galvanized iron.
Medford,	-	-	-	-	-	-	4,216	Lead lined mostly.
Melrose,	Unknown.	Unknown.	Unknown.	About 500.	Unknown.	1	3,221	Lead.
Merrimac,	-	-	204	-	-	-	204	Cement lined.
Methuen,	-	-	1,304	1	-	-	1,305	Cement lined.
Middleborough,	12	-	870	1	1	-	884	Cement lined.
Milford and Hopedale.	100	25	-	1,350	25	200	1,700	- -
Millbury,	4	1	91	-	245	-	341	Cement lined.
Millis,	All.	-	-	-	-	-	-	- -
Milton,	5	132	61	844	2	9	1,127	Lead; tin lined; galvanized iron; cast iron.
Monson,	8	10	270	-	-	-	288	Cement lined.
Montague (Turner's Falls).	-	490	-	-	-	-	490	Galvanized iron.
Nahant,	-	425	-	-	-	-	428	Galvanized iron.
Nantucket,	-	About 400.	-	About 600.	-	10	1,034	Lead and galvanized iron.
Natick,	-	1,900	15	3	4	3	1,925	Galvanized iron.
Needham,	-	39	727	38	7	-	811	Cement lined and galvanized iron.
New Bedford,	11	-	104	9,824	2	33	10,166	Lead.

Number of Service Pipes of Different Materials in Use, etc. — Continued.

City or Town.	Wrought Iron.	Galvanized Iron.	Cement lined.	Lead.	Lead lined.	Tin lined.	Total.	Material now used for New Services.
Newburyport, . .	-	-	3,177	-	-	-	3,177	Cement lined.
Newton, . . .	1,500	4,475	-	1,500	5	6	7,486	Galvanized iron.
North Adams, . .	-	3,100	-	-	-	-	3,100	Galvanized iron.
Northampton, . .	1,500	1,000	500	-	-	-	3,000	Galvanized iron.
North Andover, .	13	-	393	1	150	15	578	Lead lined.
North Attleborough,	790	-	-	10	220	-	1,020	Lead lined.
Northborough, . .	317	25	-	-	-	-	342	Galvanized iron.
Northbridge, . .	100	303	-	-	-	10	423	Galvanized iron.
North Brookfield, .	176	-	245	15	-	22	458	Lead; cement lined; tin lined.
Northfield, . .	-	43	-	-	-	-	43	Galvanized iron.
Norwood, . . .	-	200	-	1,000	-	34	1,234	Tin lined.
Orange, . . .	-	702	-	-	-	-	702	Galvanized iron.
Palmer, . . .	-	100	1	200	-	-	301	Galvanized iron.
Peabody, . . .	Few.	Nearly all.	-	-	-	-	2,280	Galvanized iron.
Pittsfield, . . .	-	About 4,000.	-	Very few.	-	-	-	Galvanized iron.
Plymouth, . .	-	50	100	2,000	-	1	2,151	Lead.
Provincetown, . .	10	203	100	-	-	-	313	Galvanized iron.
Randolph, . .	-	-	843	2	-	-	845	Cement lined.
Reading, . . .	-	49	410	3	724	-	1,191	Lead lined; galvanized iron; lead; cast iron.
Revere, . . .	-	About 1,000.	About 1,450.	6	150	-	2,610	Lead lined.
Rockland, . .	-	-	1,299	17	-	1	1,317	Cement lined.
Rockport, . . .	-	450	400	6	25	-	881	Galvanized iron.
Rutland, . . .	-	65	-	-	-	-	65	Galvanized iron.
Scituate, . . .	-	474	-	-	-	-	474	Galvanized iron.
Sharon, . . .	25	22	-	300	-	1	348	Lead.
Sheffield, . . .	-	100	-	-	-	-	100	Galvanized iron.
Shirley, . . .	-	3	113	-	-	-	116	Cement lined.
Somerville, . .	-	-	7,058	2,000	2,000	1	11,059	Lead and lead lined.
Southbridge, . .	-	Nearly all.	-	2	2	-	About 800.	Galvanized iron.
South Hadley, . .	-	35	-	400	-	-	435	Lead.
Springfield, . .	-	-	-	-	-	-	10,641	Galvanized iron.
Stockbridge, . .	-	200	-	1	-	-	201	Galvanized iron.
Stoneham, . .	-	-	About 500.	6	About 800.	25	About 1,400.	Lead lined.
Stoughton, . .	450	200	-	144	40	-	834	Lead.
Swampscott, . .	-	1,155	-	-	47	-	1,202	Lead lined.
Taunton, . . .	Very few.	-	About 4,000.	-	-	About 800.	4,837	Tin lined.

Number of Service Pipes of Different Materials in Use, etc. — Concluded.

City or Town.	Wrought Iron.	Galvanized Iron.	Cement lined.	Lead.	Lead lined.	Tin lined.	Total.	Material now used for New Services.
Wakefield, . . .	Unknown.	Very few.	About 1,700.	–	About 170.	1	1,876	Lead lined.
Walpole, . . .	–	10	554	10	25	1	600	Cement lined.
Waltham, . . .	210	–	3,350	–	–	1	3,561	Wrought iron; cement lined.
Ware, . . .	–	–	819	–	–	–	819	Cement lined.
Wareham, . . .	60	264	200	1	–	–	525	Cement lined.
Watertown, . . .	–	117	1,650	–	–	–	1,767	Galvanized iron.
Wayland, . . .	200	52	–	–	–	–	252	Galvanized iron.
Webster, . . .	–	869	–	–	–	–	869	Galvanized iron.
Wellesley, . . .	148	18	759	9	1	–	949	Cast iron; galvanized iron; cement lined.
Westborough, . . .	765	–	–	–	–	1	766	Wrought iron.
Westfield, . . .	700	1,770	–	–	–	–	2,470	Galvanized iron.
Weston, . . .	–	191	1	–	–	–	192	Galvanized iron.
Whitman, . . .	50	About 850.	About 250.	Few.	–	–	1,150	Galvanized iron.
Williamsburg, . . .	–	100	–	–	–	–	100	Galvanized iron.
Williamstown, . . .	Few.	Nearly all.	–	–	–	–	225	Galvanized iron.
Winchendon, . . .	533	–	46	–	–	–	579	Cement lined.
Winchester, . . .	–	–	400	–	1,600	–	2,000	Lead lined.
Winthrop, . . .	400	528	862	1	99	–	1,928	Galvanized iron.
Woburn, . . .	–	–	Nearly all.	–	About 200.	–	3,030	Lead lined.
Worcester, . . .	–	–	14,905	–	–	–	14,905	Cement lined and wrought steel.

NOTES.

Abington. — Some trouble has been experienced with the filling up of cement-lined service pipes.

Andover. — A few cement-lined pipes have been changed to lead-lined, owing to the filling up of the former with rust.

Attleborough. — During the years 1900 to 1905, 356 galvanized services were replaced by cement-lined pipes, as the water took up enough of the zinc and iron to make it unfit for many domestic uses.

Beverly. — Galvanized-iron service pipes give much trouble on account of rust.

Braintree. — Many of the galvanized-iron service pipes have become filled with rust.

Brookfield. — A few galvanized-iron service pipes have been replaced by lead on account of rust.

Chicopee. — Wrought-iron pipes have been replaced by lead on account of rust.

Cohasset. — Galvanized-iron services laid in salt marshes have been replaced by lead pipes on account of the action of the salt water on the outside of the iron pipes.

Concord. — Galvanized-iron pipes have given trouble on account of rust.

Easton. — Wrought-iron services have been replaced by lead-lined pipes on account of rust.

Fairhaven. — All lead service pipes were changed to galvanized-iron or tin-lined pipes on account of lead poisoning. The galvanized-iron pipes are not satisfactory, as the water acts on the zinc and iron.

Gardner. — All service pipes of other materials have been replaced by cement-lined pipes.

Hardwick. — Two lead service pipes have been replaced by cement-lined pipes on account of lead poisoning.

Haverhill. — Galvanized-iron pipes have been replaced by lead on account of rust.

Kingston. — Many lead service pipes have been replaced by tin-lined pipes on account of the danger of lead poisoning.

Lawrence. — Plain wrought-iron pipes have given trouble on account of rust, and many have been changed for galvanized-iron or lead pipes.

Lowell. — A few lead or lead-lined services have been taken out on account of lead poisoning. The plain wrought-iron and cement-lined service pipes are occasionally removed on account of rust.

Malden. — Iron service pipes have been largely replaced by lead pipes on account of rust.

Manchester. — Galvanized-iron service pipes give some trouble on account of rust.

Marlborough. — Cement-lined service pipes have given some trouble on account of rust.

Melrose. — Wrought-iron and galvanized-iron service pipes have caused trouble on account of rust, and are being rapidly replaced by lead pipes.

Middleborough. — A few lead services have been replaced by cement-lined pipes on account of danger of lead poisoning.

Milford. — Some lead service pipes have been changed on account of the danger of lead poisoning. A few wrought-iron and tin-lined services have been changed on account of rust.

Nantucket. — Many galvanized-iron service pipes have been replaced by lead on account of rust.

New Bedford. — Cement-lined service pipes are being replaced by lead pipes on account of rust.

Newton. — Plain wrought-iron services are being replaced by lead and galvanized-iron pipes.

North Andover. — Cement-lined services have given trouble on account of rust.

North Attleborough. — Plain wrought-iron services are being replaced by lead-lined pipes.

North Brookfield. — A few plain wrought-iron services have been replaced by lead or tin-lined pipes.

Norwood. — A few services have been changed from lead to tin-lined pipes on account of danger of lead poisoning.

Plymouth. — Plain wrought-iron and cement-lined services are being replaced by lead on account of rust.

Provincetown. — Cement-lined pipes are being replaced by galvanized-iron pipes.

Revere. — Wrought-iron services are being replaced by lead-lined pipes on account of rust.

Sharon. — Plain wrought-iron and galvanized-iron services are being replaced by lead on account of rust.

South Hadley. — A few galvanized-iron services have been replaced by lead pipes on account of rust.

Swampscott. — Galvanized-iron pipes are being replaced by lead-lined.

Wakefield. — Cement-lined pipes are being replaced by lead-lined pipes.

Wareham. — Plain wrought-iron and galvanized-iron pipes have given trouble on account of rust.

Whitman. — Plain wrought-iron and cement-lined services have given trouble on account of rust.

Winchester. — Cement-lined services have been changed to lead-lined on account of rust.

From this table it will be seen that in 3 cities, viz., Chelsea, Everett and Fall River, all of the service pipes are of lead, while the service pipes are chiefly of lead in 23 other cities and towns, as follows: —

Ashburnham.	Lawrence.	Palmer.
Boston.	Malden.	Plymouth.
Chicopee.	Milford.	Reading.
Easton.	Millbury.	Sharon.
Haverhill.	Milton.	South Hadley.
Hopedale.	Nantucket.	Stoneham.
Ipswich.	New Bedford.	Winchester.
Kingston.	Norwood.	

Lead or lead-lined pipes are also used to a very considerable extent in Andover, Braintree, Lynn, Melrose, Newton, North Andover, North Attleborough, Somerville, Stoughton and Wakefield. No lead whatever is used for service pipes in 83 cities and towns.

In 12 cities and towns the service pipes are chiefly of plain wrought iron, while in 53 the service pipes are chiefly of galvanized iron and in 49 they are chiefly of cement-lined wrought iron. Tin-lined iron and tin-lined lead pipe have recently been introduced, but thus far they are in general use for service pipes in only one town, — Fairhaven. Considerable numbers of them, however, are in use in Kingston, Milford and Hopedale, where cases of lead poisoning have been caused by the use of lead service pipes, and they are used to some extent in several other places.

For new services and for renewing service pipes, lead or lead-lined pipes are used almost exclusively in 28 cities and towns, as follows: —

Andover.	Lawrence.	Sharon.
Brookfield.	Lynn.	Somerville.
Chelsea.	Malden.	South Hadley.
Chicopee.	Melrose.	Stoneham.
Concord.	New Bedford.	Stoughton.
Easton.	North Andover.	Swampscott.
Everett.	North Attleborough.	Wakefield.
Fall River.	Plymouth.	Winchester.
Haverhill.	Revere.	Woburn.
Ipswich.		

It is worthy of note that the town of North Andover, at the time of the introduction of its water supply, requested, on Sept. 28, 1898, the opinion of the Board as to the probable effect of the water of the proposed source of supply upon lead or lead-lined pipes; and the Board advised the town to avoid the use of lead in connection with its proposed system of water supply. The use of lead for service pipes when the works were first built was avoided, but in recent years lead-lined pipe has been used.

In addition to the foregoing places, lead or lead-lined pipes are used in part for new services in the following cities and towns: —

Ashburnham.	Marlborough.	North Brookfield.
Braintree.	Milton.	Reading.
Framingham.	Nantucket.	

Cement-lined pipes are used for renewals and for new services in 34 cities and towns, and they are used in part in 9 places. Galvanized iron only is used almost exclusively for new services and renewals in 65 cities and towns, and in part in 12 cities and towns.

From the information furnished by the various water departments, it appears that more or less trouble is invariably experienced in the use of

plain wrought iron from the rusting of the pipes, and it has been necessary to renew many of the services of this material after they have been in use for a few years. The use of galvanized-iron pipes has also been unsatisfactory in many cases, and there are 44 places which report considerable trouble from rusting. The cement-lined pipes have given much less trouble than the galvanized iron, and only 8 places report any serious trouble with pipes of this material. As before stated, only comparatively few tin-lined pipes are in use, and in only 1 case has any trouble from the use of these pipes been reported.

EXPERIMENTS

UPON THE

Removal of Organisms from the Waters of Ponds and Reservoirs

BY THE

USE OF COPPER SULPHATE.

By X. H. Goodnough, *Chief Engineer*.

EXPERIMENTS UPON THE REMOVAL OF ORGANISMS FROM THE WATERS OF PONDS AND RESERVOIRS BY THE USE OF COPPER SULPHATE.

The attention of the State Board of Health was first called to the possibility of the removal of microscopic organisms from ponds and reservoirs by the use of copper sulphate by Dr. George T. Moore, physiologist and algologist of the United States Department of Agriculture, and experiments to test the effect of the use of this substance were begun in 1903. For obvious reasons it was necessary that these tests should first be made with waters which were not used for drinking, and it was important also to select sources of which the physical features and the biological history were well known.

Certain ponds and storage reservoirs, situated chiefly in the metropolitan district near Boston, which had been used formerly as sources of water supply but now abandoned for that purpose, fulfilled these conditions very satisfactorily, since the physical condition and biological history of these reservoirs were as well known as were those of any of the sources of water supply in use.

The sources which have been used in the experiments are the Arlington, Lexington and Quincy storage reservoirs and Jamaica Pond, — formerly used as sources of water supply by portions of the Metropolitan Water District, — and Belchertown Reservoir, once used as a source of water supply by the city of Springfield. In addition to the reservoirs mentioned, the general results of experiments upon the application of copper sulphate to two other ponds in the State by persons not connected with the State Board of Health have been observed.

In the beginning the application of the copper sulphate was made under the advice of Dr. Moore by his assistants, Messrs Kellerman and Robinson. In all subsequent experiments the field work has been carried on by Mr. Henry E. Mead of this department. The reservoirs have been visited frequently during the progress of the experiments and the physical conditions carefully noted.

A great number of chemical and biological analyses of the waters before and after the application of copper has been made, and numerous samples have been analyzed to determine the quantity of copper present in the various waters at different times and in the mud in the bottoms of these reservoirs. The analyses have been made in the laboratory of the Board, under the direction of the chemist, Mr. H. W. Clark.

Arlington Reservoir.

Arlington Reservoir is formed by a dam on Mill Brook, and was constructed in the year 1872 for the purpose of supplying water to the town of Arlington.

Its area was originally estimated to be 31 acres and its capacity 90,000,000 gallons, and these figures were used in determining the amount of copper sulphate to be applied to the reservoir. Subsequently, upon surveying the reservoir to check the results of the test, it was found that its area was about 29 acres and its capacity 66,000,000 gallons, and the proportion of copper sulphate applied has been figured on the basis of the new survey. The general depth of the reservoir is about 8½ feet, though there are places where the depth is less than 3 feet. The bottom is in most places covered with mud, but there are very few grasses or other aquatic plants growing in the reservoir. The watershed has an area of about 1.13 square miles, and consists largely of meadow and cultivated upland.

The water of the reservoir has always been characterized by a high color and the presence of a large quantity of organic matter; and the quality of the water has usually been very objectionable in the summer season, owing to the presence of excessive numbers of organisms of various kinds. Nearly always in the late summer and early fall large numbers of the Cyanophyceæ, such as *Anabæna* and *Clathrocystis,* have been present, and the water has also been affected by great numbers of organisms of other kinds at nearly all seasons of the year.

The water of the reservoir was examined at frequent intervals by means of chemical and microscopical analyses from 1887 until 1899; but, its use having been abandoned as a source of public water supply, the examinations were discontinued in the latter year. They were begun again early in 1903, and have been continued, except in the winter season, up to the present time.

Copper sulphate was first applied to this reservoir on Aug. 5, 1903, and this was the first of the experiments made by the Board upon the removal of microscopic organisms from the waters of ponds and reservoirs by the use of this substance. The organic growths in the reservoir in the earlier portion of this year had been those characteristic of this source. Diatomaceæ, especially *Synedra,* appeared early in the year and grew in great abundance up to the middle of July, when they practically disappeared. At the time of the first treatment the chief organism present was *Scenedesmus,* and the water had a decided turbidity and a marked greenish hue. The Cyanophyceæ began to appear in considerable numbers just before treatment.

About 300 pounds of copper sulphate were applied to the water on Aug. 5, 1903, under the direction of Mr. R. T. Robinson of the United States Department of Agriculture, assisted by Mr. Mead. The copper sulphate was applied by trailing it in six loosely woven burlap sacks at the stern of a boat. The boat was rowed around the reservoir in approximately concentric circles until all of the copper sulphate had been dissolved. The quantity applied amounted to 1 part of copper sulphate to 1,800,000 parts of water.

After the copper sulphate was applied samples of the water were collected daily for the next three days, and then at less frequent intervals up to September 8. The only noticeable effect of the application of the copper sulphate upon the water of the reservoir was a reduction in the number of Cyanophyceæ, of which, as already noted, small numbers had appeared just before the copper sulphate was applied. The other organisms grew in greater numbers than before, and on September 8, four weeks after the treatment, the number of organisms was more than twice as great as before the copper sulphate was applied. The chemical analyses did not show any material change in the organic matter or in other respects, except a decrease in color, which usually occurs in all reservoirs at this season. The appearance of the reservoir was even more objectionable than previous to the treatment.

The results of the chemical and microscopical analyses of the water of the reservoir during 1903 are presented in the following tables: —

Chemical Examinations of Water from Arlington Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1903.																
45082	Apr. 23	Decided.	Cons.	0.98	Faintly vegetable.	Distinctly vegetable.	6.20	2.50	.0020	.0424	.0316	.0108	.45	.0210	.0003	0.88	2.3
45179	May 4	Slight.	Cons.	0.82	Faintly vegetable.	Distinctly vegetable and sweetish.	6.35	2.60	.0056	.0428	.0304	.0124	.46	.0150	.0001	0.85	2.1
45341	May 18	Slight.	Cons., green.	0.80	Faintly vegetable.	Faintly vegetable.	5.85	2.60	.0022	.0326	.0244	.0082	.51	.0080	.0004	0.77	2.1
45615	June 1	Decided, green.	Cons., green.	0.55	Distinctly unpleasant, decaying organisms.	Decidedly unpleasant, decaying organisms.	6.15	2.50	.0008	.0508	.0260	.0248	.53	.0000	.0001	0.71	2.3
45824	June 16	V. slight.	Cons., green and cyclops.	0.63	Distinctly unpleasant, decaying organisms.	Distinctly unpleasant, decaying organisms.	6.00	2.45	.0092	.0368	.0320	.0048	.53	.0010	.0001	0.74	2.2
46012	June 29	Slight.	Cons.	1.06	Faintly vegetable.	Distinctly vegetable and sweetish.	6.95	3.55	.0080	.0420	.0288	.0132	.45	.0080	.0007	1.17	2.1
46219	July 13	Decided.	Cons., scum.	0.78	Distinctly unpleasant.	Decidedly unpleasant.	6.10	2.80	.0012	.0464	.0332	.0132	.49	.0000	.0000	1.06	2.1
46453	July 27	Decided.	Cons.	0.84	Distinctly vegetable and unpleasant.	Decidedly musty, organisms.	6.40	3.15	.0032	.0520	.0380	.0140	.47	.0000	.0000	1.02	2.3
46689	Aug. 10	Decided.	Cons., green.	0.82	Distinctly unpleasant.	Distinct of dulse.	7.50	3.35	.0152	.0416	.0228	.0188	.51	.0040	.0001	0.92	2.5
46886	Aug. 24	Decided.	Cons., green.	0.65	Distinctly unpleasant, organisms.	Distinctly unpleasant, organisms.	6.45	2.85	.0000	.0512	.0290	.0222	.56	.0010	.0000	0.87	2.2
47084	Sept. 8	Slight.	Cons., green.	0.50	Faintly unpleasant.	Decidedly grassy, organisms.	7.00	2.85	.0018	.0456	.0280	.0176	.55	.0140	.0000	0.75	1.8

Arlington Reservoir. — *Table showing Number of Principal Organisms per Cubic Centimeter.*

	1903.															
	April 23.	May 4.	May 18.	June 1.	June 16.	June 29.	July 13.	July 27.	Aug. 4.	Aug. 5.	Aug. 6.	Aug. 7.	Aug. 8.	Aug. 10.	Aug. 24.	Sept. 8.
Days after last treatment,	-	-	-	-	-	-	-	-	-	-	1	2	3	5	19	34
Number of samples,	1	1	1	1	1	1	1	1	1	-	1	1	3	4	1	1
Diatomaceæ:—										Treatment: 1 part copper sulphate to 1,800,000 parts water.						
Asterionella,	500	736	464	32	124	2,592	0	0	24		16	16	5	12	32	40
Cyclotella,	0	16	40	0	0	0	0	0	0		0	0	0	0	0	0
Fragilaria,	0	0	0	0	0	0	0	0	176		120	40	32	18	72	0
Melosira,	1,124	840	432	0	116	224	0	32	48		200	64	45	118	32	390
Synedra,	180	336	2,616	2,280	2,160	4,420	3,040	130	166		336	136	157	129	112	550
Cyanophyceæ,	**20**	**40**	**32**	**44**	**12**	**24**	**96**	**120**	**228**		**30**	**12**	*	**10**	**8**	**20** [1]
Anabæna,	4	0	16	34	0	0	0	0	16		0	0	0	0	0	0
Aphanizomenon,	0	0	0	0	0	0	40	0	0		0	0	0	0	0	0
Chroöcoccus,	0	40	0	0	0	0	0	0	0		0	0	0	0	0	0
Cœlosphærium,	4	0	16	10	12	24	48	120	208		28	12	*	10	8	0
Algæ:—																
Cosmarium,	0	0	8	0	0	0	0	112	376		208	256	296	440	1,384	250
Protococcus,	72	336	664	700	424	416	3,056	80	32		304	240	493	655	2,008	220
Scenedesmus,	1,208	2,192	3,128	720	2,600	5,640	160	5,584	2,432		4,536	4,704	3,141	6,624	3,912	7,240
Staurastrum,	308	112	160	1,920	500	168	344	208	160		216	128	64	103	176	80
Infusoria,	**768**	**32**	**56**	**60**	**8**	**16**	**0**	**16**	**114**		**168**	**112**	**168**	**101**	**50**	**2,870** [2]
Monas,	736	16	56	50	8	0	0	0	104		152	96	160	86	48	0
Total organisms,	4,441	5,006	7,694	5,818	6,004	13,658	6,758	6,482	3,950		6,264	5,838	4,537	8,375	8,026	11,840

* The organism was present in some samples, but not in others, the average number of organisms being less than 1.

[1] *Glœocapsa.* [2] *Chlamydomonas.*

The condition of the reservoir early in 1904 was very similar to its condition in 1903. Growths of *Asterionella, Melosira, Synedra* and *Scenedesmus* appeared, culminating late in May, when the total number of organisms present was more than 18,000 and consisted chiefly of *Synedra* and *Scenedesmus.* These two organisms then diminished greatly in numbers, but the organism *Staurastrum* increased until the reservoir contained in the latter part of July great numbers of this organism. An examination of the reservoir at this time showed that the water was green in color, very turbid, and contained many blue-green specks or clots of organisms. The Cyanophyceæ had also made their appearance in small numbers.

On July 28, 1904, 150 pounds of copper sulphate were applied to the reservoir, this quantity being equivalent to 1 part of copper sulphate in 3,650,000 parts of water. Samples of the water were collected frequently after this treatment and the reservoir carefully observed. The results of the examinations showed that after the application of copper sulphate the Cyanophyceæ practically disappeared within two days; but the treatment had practically no effect upon the numbers of other organisms present, the number of *Staurastrum* remaining about the same as in the days before copper sulphate was applied, while the number of *Scenedesmus* increased considerably.

It was then determined to apply a much greater quantity of copper sulphate, and on August 10, 750 pounds of this chemical were dissolved in the water in the same manner as in the previous treatment, this quantity being equivalent to 1 part of copper sulphate to 730,000 parts of water. *Staurastrum* decreased gradually for the first five days after the treatment and then much more rapidly, until, on August 30, the number had fallen from about 6,000 to 171; but other organisms, especially *Protococcus* and *Scenedesmus,* increased greatly. While a considerable improvement had taken place in the condition of the reservoir, at the end of the first week after the application of the copper sulphate the turbidity again rapidly increased, until on August 30 the water was in a worse condition than at any previous time during the season.

At the end of a week after the application of copper sulphate to the reservoir on August 10, about a dozen perch from 3 to 6 inches long were found dead near the outlet of the reservoir, and in the next two days more than 50 fish were found dead in the same locality. All of these were white perch. Apparently none of the other fish in the reservoir were affected, and evidently very few perch were killed, since boys were catching perch, which appeared to be in a normal condition, from the shores of the reservoir at this time.

On August 30 copper sulphate was applied to the reservoir for a third time in this year, and again in a quantity amounting to 750 pounds, or 1 part in 730,000 parts of water. The numbers of organisms decreased greatly for several days after this treatment, and on the 6th of September the total number present in the reservoir was less than a third of the number found there on August 30, before the copper sulphate was applied. From this time, however, the number of organisms increased rapidly, until, by the middle of October, the number was greater than at any time during the year except in May, and the condition of the reservoir was more objectionable than ever. The numbers then gradually fell off with the approach of winter.

The results of the chemical and microscopical analyses of the water of the reservoir during 1904 are given in the following tables: —

Chemical Examinations of Water from Arlington Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1904.																
49295	Apr. 26	Decided.	Cons., green; vegetable matter.	.70 [1]	Faintly unpleasant.	Distinctly unpleasant, decaying organisms.	6.00	2.55	.0020	.0396	.0276	.0120	.51	.0240	.0003	.75	2.6
49378	May 9	Decided, green.	Cons., green.	.86	Distinctly vegetable, sweet.	Distinctly vegetable, sweet.	5.90	2.65	.0014	.0214	.0126	.0088	.50	.0270	.0004	.84	2.5
49510	May 24	Decided, green.	Cons., green.	.86	Distinctly vegetable and sweet, Anabæna.	Distinctly vegetable and sweet, Anabæna.	6.00	2.80	.0020	.0360	.0254	.0106	.55	.0210	.0005	.90	2.7
49596	June 6	Decided.	Cons.	.82	Distinctly unpleasant, decaying Algæ.	Decidedly unpleasant, decaying Algæ.	6.70	3.05	.0048	.0396	.0304	.0092	.59	.0180	.0005	.87	2.6
49735	June 20	Slight.	Cons., green.	.82	Distinctly vegetable and unpleasant.	Distinctly vegetable and unpleasant.	6.95	3.25	.0040	.0448	.0344	.0104	.58	.0050	.0006	.88	2.7
49833	June 27	Slight, green.	Cons., green.	.74	Distinct of decaying organisms.	Decided of decaying organisms.	6.95	2.90	.0028	.0504	.0348	.0156	.60	.0030	.0005	.85	2.2
49955	July 5	Decided, green.	Cons., green.	.68	Distinctly disagreeable, decaying Algæ.	Decidedly disagreeable, decaying Algæ.	7.20	3.40	.0008	.0612	.0300	.0312	.62	.0020	.0004	.88	2.6
50044	July 11	Slight.	Cons., green; organisms.	.70	Distinctly vegetable and unpleasant, decaying Algæ.	Decidedly vegetable and unpleasant, decaying Algæ.	8.60	4.70	.0000	.0444	.0240	.0204	.60	.0000	.0000	.87	2.7
50203	July 18	Decided, green.	Cons., organisms.	.54	Distinctly disagreeable, decaying organisms.	Decidedly disagreeable, decaying organisms.	7.80	3.15	.0004	.0432	.0280	.0152	.62	.0000	.0004	.90	2.3
50322	July 25	Decided, green.	Cons., also scum, organisms.	.53	Distinctly unpleasant, organisms.	Decidedly unpleasant, organisms.	7.70	3.60	.0004	.0528	.0280	.0248	.65	.0010	.0000	.85	2.5
–	July 28	–	–	.53	– –	– –	7.82	3.62	.0010	.0615	.0295	.0320	.66	.0020	.0000	.86	2.4
–	July 29	–	–	.47	– –	– –	7.82	3.55	.0000	.0505	.0320	.0185	.63	.0035	.0000	.83	2.6
–	July 30	–	–	.49	– –	– –	8.17	3.62	.0000	.0490	.0317	.0173	.62	.0060	.0000	.82	2.6
50449	Aug. 1	Decided, green.	Cons., organisms.	.50	Decidedly disagreeable.	Decidedly disagreeable.	8.25	4.05	.0000	.0630	.0350	.0280	.67	.0080	.0000	.90	2.6
–	Aug. 3	–	–	.45	– –	– –	7.92	3.65	.0020	.0520	.0282	.0238	.64	.0005	.0001	.82	2.6

50555	Aug. 8	Decided.	Cons., green; organisms.	.45	Decidedly disagreeable, organisms.	Decidedly disagreeable, organisms.	7.90	3.70	.0000	.0470	.0280	.0190	.63	.0010	.0001	.80	2.6
–	Aug. 11	–	–	.47	– –	– –	8.22	3.90	.0030	.0470	.0307	.0163	.65	.0000	.0000	.97	2.6
–	Aug. 12	–	–	.44	– –	– –	7.85	3.50	.0065	.0515	.0315	.0200	.66	.0000	.0000	.87	2.6
–	Aug. 13	–	–	.44	– –	– –	8.27	3.72	.0100	.0485	.0332	.0153	.65	.0020	.0001	.86	2.7
–	Aug. 15	–	–	.44	– –	– –	7.78	3.52	.0313	.0460	.0303	.0157	.67	.0030	.0000	.84	2.7
–	Aug. 17	–	–	.48	– –	– –	7.80	3.55	.0225	.0400	.0307	.0093	.66	.0030	.0001	.81	2.6
–	Aug. 19	–	–	.45	– –	– –	8.10	3.60	.0155	.0540	.0347	.0193	.67	.0040	.0001	.80	2.7
–	Aug. 22	–	–	.45	– –	– –	7.82	3.40	.0040	.0485	.0332	.0153	.66	.0035	.0002	.81	2.7
–	Aug. 25	–	–	.46	– –	– –	7.60	3.27	.0008	.0515	.0275	.0240	.67	.0020	.0002	.72	2.7
–	Aug. 27	–	–	.44	– –	– –	7.57	3.32	.0009	.0507	.0292	.0215	.68	.0025	.0002	.72	2.6
–	Aug. 29	–	–	.37	– –	– –	7.58	3.40	.0007	.0512	.0262	.0250	.70	.0017	.0001	.76	2.6
–	Aug. 31	–	–	.38	– –	– –	8.02	3.32	.0012	.0535	.0322	.0213	.69	.0015	.0001	.75	2.7
–	Sept. 2	–	–	.43	– –	– –	7.90	3.40	.0010	.0475	.0217	.0258	.69	.0020	.0000	.80	2.6
–	Sept. 6	–	–	.45	– –	– –	7.97	3.47	.0009	.0440	.0292	.0148	.70	.0037	.0001	.77	2.7
–	Sept. 8	–	–	.45	– –	– –	7.87	3.30	.0007	.0460	.0257	.0203	.67	.0030	.0000	.70	2.6
–	Sept. 12	–	–	.45	– –	– –	7.58	3.08	.0007	.0458	.0275	.0183	.70	.0020	.0000	.67	2.5
–	Sept. 15	–	–	.43	– –	– –	7.05	2.92	.0002	.0465	.0252	.0213	.66	.0010	.0000	.67	2.5
–	Sept. 20	Decided, green.	Cons., green.	.44	Distinctly sweet, organisms.	Decidedly sweet, organisms.	7.60	2.90	.0012	.0720	.0560	.0160	.65	.0000	.0000	.75	2.7
51294	Sept. 21	–	–	.38	– –	– –	7.15	2.85	.0010	.0490	.0257	.0233	.65	.0030	.0000	.73	2.5
–	Sept. 23	–	–	.41	– –	– –	7.25	3.07	.0011	.0465	.0262	.0203	.65	.0000	.0000	.89	2.7
–	Sept. 27	–	–	.37	– –	– –	7.02	2.85	.0017	.0480	.0257	.0223	.66	.0000	.0000	.70	2.6
–	Oct. 1	–	–	.36	– –	– –	6.97	2.72	.0020	.0465	.0250	.0215	.67	.0017	.0001	.69	2.6
–	Oct. 7	–	–	.34	– –	– –	7.17	2.77	.0016	.0432	.0242	.0190	.67	.0005	.0000	.69	2.9

[1] Turbid.

Chemical Examinations of Water from Arlington Reservoir — Concluded.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1904.																
51626	Oct. 11	Decided, green.	Cons., green.	.35	Faintly unpleasant, organisms.	Distinctly unpleasant, organisms.	7.20	2.90	.0014	.0415	.0240	.0175	.68	.0040	.0000	.64	2.6
51705	Oct. 17	Decided, green.	Cons., green.	.34	Faintly unpleasant.	Distinctly vegetable and grassy.	7.20	3.00	.0014	.0400	.0250	.0150	.69	.0010	.0000	.63	2.7
51805	Oct. 24	Decided, green.	Cons., green.	.34	Distinctly vegetable.	Decidedly unpleasant, organisms.	6.90	2.70	.0006	.0480	.0235	.0245	.68	.0020	.0000	.65	2.9
51909	Oct. 31	Decided, green.	Cons., green.	.35	Faintly vegetable.	Distinctly disagreeable, organisms.	6.85	2.70	.0014	.0440	.0260	.0180	.70	.0020	.0001	.64	2.5
-	Nov. 3	-	-	.31	- -	- -	6.82	2.72	.0018	.0380	.0205	.0175	.71	.0010	.0000	.56	2.5
51982	Nov. 7	Decided, green.	Cons., green.	.32	Faintly vegetable.	Decided of organisms.	6.80	2.70	.0014	.0430	.0230	.0200	.72	.0010	.0001	.62	2.3
52060	Nov. 14	Decided.	Cons.	.26	V. faintly vegetable.	Decided of organisms.	6.30	2.20	.0024	.0395	.0225	.0170	.69	.0030	.0001	.58	2.3
52159	Nov. 21	Slight.	Cons.	.32	Faintly unpleasant, organisms.	Distinctly unpleasant, organisms.	6.35	2.50	.0026	.0360	.0240	.0120	.67	.0050	.0001	.62	2.3
52225	Nov. 28	Decided, green.	Cons., green.	.34	Faintly unpleasant and vegetable, organisms.	Faintly unpleasant and vegetable, organisms.	7.75	2.70	.0032	.0372	.0264	.0108	.76	.0040	.0001	.62	2.7
52320	Dec. 5	Slight.	Cons., green.	.34	Faintly unpleasant, organisms.	Distinctly unpleasant, organisms.	8.30	2.85	.0040	.0352	.0128	.0224	.84	.0030	.0001	.78	2.9
52472	Dec. 14	Slight.	V. slight, cyclops.	.30	V. faintly vegetable.	Distinctly vegetable and unpleasant.	7.35	2.85	.0020	.0336	.0212	.0124	.84	.0060	.0002	.58	2.9

Arlington Reservoir. — Table showing Number of Principal Organisms per Cubic Centimeter.

	1904.														
	April 26.	May 9.	May 24.	June 6.	June 20.	June 27.	July 5.	July 11.	July 18.	July 25.	July 26.	July 27.	July 28.	July 28.	July 29.
Days after last treatment,	265	278	293	306	320	327	335	341	348	355	356	357	358	–	1
Number of samples,	1	1	1	1	1	1	1	1	1	1	4	2	6	–	6
Diatomaceæ:—														Treatment: 1 part copper sulphate to 3,650,000 parts water.	
Asterionella,	2,888	3,928	42	4	0	0	0	8	0	0	0	0	0		0
Cyclotella,	2,560	0	0	32	0	0	8	8	0	0	0	0	0		0
Fragilaria,	80	144	38	40	40	124	152	48	0	76	0	0	37		24
Melosira,	520	2,096	364	32	16	72	16	0	48	8	28	0	6		16
Synedra,	752	6,016	12,336	780	8	48	224	8	32	0	0	40	*		0
Cyanophyceæ,	**0**	**0**	**4**	**4**	**0**	**4**	**16**	**2**	**40**	**30**	**34**	**8**	**310**		**49**
Anabæna,	0	0	4	0	0	0	0	0	0	2	0	0	6		0
Aphanizomenon,	0	0	0	0	0	0	0	0	0	18	24	0	283		43
Chroöcoccus,	0	0	0	4	0	0	0	0	16	0	8	0	0		0
Cœlosphærium,	0	0	0	0	0	4	8	2	24	2	0	0	*		*
Algæ:—															
Cosmarium,	0	8	4	20	52	108	216	136	56	58	42	84	74		39
Protococcus,	112	504	130	44	68	108	176	48	88	0	44	16	0		0
Scenedesmus,	1,264	2,288	5,496	4,384	528	368	608	288	272	30	244	420	88		109
Staurastrum,	0	8	16	188	304	3,604	7,264	7,832	7,136	1,376	5,396	7,400	4,411		6,197
Infusoria,	**24**	**30**	**22**	**0**	**4**	**4**	**16**	**0**	**0**	**18**	**28**	**0**	**0**		**0**
Monas,	0	0	2	0	0	0	0	0	0	0	0	0	0		0
Total organisms,	8,402	15,404	18,544	5,656	1,078	4,496	8,802	8,380	7,817	1,604	5,834	7,971	4,939		6,445

* The organism was present in some samples, but not in others, the average number of organisms being less than 1.

Arlington Reservoir. — Table showing Number of Principal Organisms per Cubic Centimeter — Continued.

	1904.														
	July 30.	August 1.	August 3.	August 8.	August 9.	August 10.	August 11.	August 12.	August 13.	August 15.	August 17.	August 19.	August 22.	August 25.	August 27.
Days after last treatment,	2	4	6	11	12	-	1	2	3	5	7	9	12	15	17
Number of samples,	6	1	6	1	4	-	6	6	6	7	6	6	2	6	6
Diatomaceæ:—						Additional treatment: 1 part copper sulphate to 730,000 parts water. Resulting concentration: 1:460,000.									
Asterionella,	0	8	0	8	1		0	3	1	3	3	1	0	4	11
Cyclotella,	0	0	0	0	0		4	3	0	9	0	0	0	3	3
Fragilaria,	28	104	73	48	84		79	52	51	55	0	20	104	61	127
Melosira,	9	0	16	24	20		48	45	43	34	0	28	60	95	159
Synedra,	0	8	11	0	36		15	40	11	18	0	11	28	5	56
Cyanophyceæ,	**39**	**0**	**3**	**0**	**1**		**0**	*	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Anabæna,	0	0	0	0	0		0	0	0	0	0	0	0	0	0
Aphanizomenon,	32	0	0	0	0		0	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0	1	0	0		0	0	0	0	0	0	0	0	0
Cœlosphærium,	1	0	*	0	0		0	0	0	0	0	0	0	0	0
Algæ.—															
Cosmarium,	29	48	105	144	190		104	95	92	69	80	136	372	709	2,092
Protococcus,	0	0	35	288	472		479	340	472	607	999	592	3,272	3,890	3,936
Scenedesmus,	69	512	893	816	1,084		1,580	1,496	1,047	865	667	768	1,584	2,417	2,268
Staurastrum,	4,349	5,488	7,068	7,640	6,430		6,220	5,916	5,989	5,194	3,568	3,389	544	287	316
Infusoria,	**3**	**24**	**7**	**0**	**12**		**4**	**13**	**49**	**171**	**121**	**821**	**72**	**29**	**21**
Monas,	0	0	4	0	0		0	0	37	138	96	792	40	15	19
Total organisms,	4,537	6,200	8,231	8,978	8,377		8,585	8,032	7,787	7,072	5,491	5,807	6,221	8,041	9,565

* The organism was present in some samples, but not in others, the average number of organisms being less than 1.

Arlington Reservoir. — Table showing Number of Principal Organisms per Cubic Centimeter — Continued.

	1904.													
	August 29.	August 30.	August 30.	August 31.	September 2.	September 6.	September 8.	September 12.	September 15.	September 16.	September 20.	September 21.	September 23.	September 27.
Days after last treatment,	19	20	–	1	3	7	9	13	16	17	21	22	24	28
Number of samples,	7	3	–	6	6	7	6	7	5	2	1	6	6	7
Diatomaceæ:—			Additional treatment: 1 part copper sulphate to 730,000 parts water. Resulting concentration: 1:710,000.											
Asterionella,	7	11		15	8	9	9	2	10	4	0	9	3	14
Cyclotella,	1	0		0	5	0	0	0	0	0	0	0	0	1
Fragilaria,	132	53		47	55	35	144	81	250	132	200	161	102	65
Melosira,	59	67		41	56	23	56	63	103	120	104	101	76	76
Synedra,	36	32		1	28	47	1	15	64	20	8	88	48	12
Cyanophyceæ,	**0**	**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Anabæna,	0	0		0	0	0	0	0	0	0	0	0	0	0
Aphanizomenon,	0	0		0	0	0	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0		0	0	0	0	0	0	0	0	0	0	0
Cœlosphærium,	0	0		0	0	0	0	0	0	0	0	0	0	0
Algæ:—														
Cosmarium,	1,805	1,932		2,084	1,867	730	484	310	263	300	672	965	862	26
Protococcus,	4,628	4,771		2,717	1,339	1,206	1,708	2,315	1,986	2,076	2,736	3,946	3,141	4,303
Scenedesmus,	2,229	2,149		1,275	1,116	797	789	869	1,257	1,260	1,192	1,338	1,102	1,177
Staurastrum,	203	171		137	171	66	89	64	105	104	72	76	90	46
Infusoria,	**14**	**3**		**5**	**11**	**7**	**1**	**8**	**27**	**64**	**56**	**141**	**49**	**17**
Monas,	12	0		1	8	7	1	8	25	28	56	126	15	16
Total organisms,	9,601	9,541		6,717	4,964	3,035	3,412	4,153	4,690	4,678	5,714	7,182	5,553	5,775

Arlington Reservoir. — Table showing Number of Principal Organisms per Cubic Centimeter — Concluded.

	1904.													
	October 1.	October 3.	October 7.	October 11.	October 17.	October 24.	October 31.	November 3.	November 7.	November 14.	November 21.	November 28.	December 5.	December 14.
Days after last treatment,	32	34	38	42	48	55	62	65	69	76	83	90	97	106
Number of samples,	6	1	6	1	1	1	1	2	1	1	1	1	1	1
Diatomaceæ:—														
Asterionella,	25	48	54	64	112	344	920	788	520	816	248	912	1,148	944
Cyclotella,	0	0	0	0	0	0	0	0	8	0	0	0	8	0
Fragilaria,	228	248	132	40	0	176	0	168	40	136	80	0	0	0
Melosira,	171	104	344	408	248	544	360	523	480	272	16	16	0	0
Synedra,	61	64	111	232	240	32	360	126	112	40	32	128	156	204
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Anabæna,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphanizomenon,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algæ:—														
Cosmarium,	23	40	39	32	48	40	70	31	24	40	0	8	4	0
Protococcus,	3,205	5,408	4,650	5,296	7,780	7,520	7,470	5,306	4,408	6,440	5,136	4,696	3,408	1,424
Scenedesmus,	1,099	1,616	2,241	2,792	3,120	2,832	2,480	1,942	1,968	1,424	880	520	276	152
Staurastrum,	37	64	43	32	40	48	30	39	32	56	24	24	32	24
Infusoria,	**9**	**8**	**5**	**0**	**8**	**0**	**50**	**32**	**0**	**8**	**0**	**8**	**8**	**8**
Monas,	0	0	4	0	0	0	0	28	0	0	0	0	0	0
Total organisms,	4,925	7,662	7,674	8,596	11,612	11,564	11,786	9,036	7,714	9,370	6,550	6,358	5,092	2,776

During the present year (1905) the condition of the reservoir has been carefully observed, and chemical and microscopical analyses of the water have been made at frequent intervals, but no copper has been applied to the reservoir. It has been noted that the Cyanophyceæ practically disappeared in 1903, after the first application of copper sulphate. They reappeared just before the treatment of July 28, 1904, but quickly disappeared thereafter, and none was present during the remainder of the year. In 1905 the Cyanophyceæ appeared as usual toward the end of July, and attained their maximum growth for this year on September 15. They had practically disappeared by the end of October. The only other organism materially affected by the treatments in 1904 was *Staurastrum*, which practically disappeared after the second treatment, when copper sulphate was applied in a quantity equivalent to 1 part in 730,000 parts of water. The organism appeared again in large numbers during the month of July, 1905, but the number quickly fell off and remained small during the remainder of the year.

The condition of the reservoir, as shown by chemical analyses, differed little if any from its condition in previous years, nor was any material change noted in the appearance of the water.

Quantity of Copper Sulphate present in the Water and Mud of Arlington Reservoir. — The first analysis of water from Arlington Reservoir and of mud from its bottom for the determination of the quantity of copper present was made on July 12, 1904. Copper sulphate had been applied in the previous year in a quantity equivalent to 1 part in 1,800,000 parts of water, but no copper was present in the sample of July 12. The analysis of a sample of mud from the bottom of the reservoir showed the presence of 2.36 parts of copper sulphate in 100,000 parts of dry mud. Frequent analyses to determine the quantity of copper present were made from July 28, 1904, when copper sulphate was first applied, to December 14 in that year, and samples of mud were collected frequently during this period for analysis. The results show the presence of copper in the reservoir water in quantities nearly as great as those applied, though gradually diminishing after each treatment. After the last application of copper sulphate to the reservoir, on Aug. 30, 1904, the quantity of copper present in the reservoir was equivalent to 1 part of copper sulphate in 660,000 parts of water. This was the last application of copper sulphate, and the quantity present in the water diminished rapidly, until, on Dec. 14, 1904, the quantity amounted to 1 part in 11,600,000 parts of water. The quantity of copper sulphate present in the mud, however, which was found to be 2.36 parts per 100,000 of dry mud on July 12, 1904, increased to an average of about 320 parts per 100,000 in the month of October, and then diminished, the last determination, made

on Jan. 9, 1905, showing the presence of 137 parts of copper sulphate in 100,000 parts of dry mud. In 1905 the quantity of copper present in the water varied from time to time; but three samples, collected between June 23 and October 3, each contained 1 part of copper sulphate in 21,000,000 parts of water.

It is evident from these determinations that much of the copper sulphate applied settled to the bottom of the reservoir, and of course much of it was removed in the water passing out over the overflow, but the results of the analyses show that copper was taken up by the water from the mud at the bottom for more than a year after copper sulphate was last applied, probably at times when the water was agitated by high winds.

It has not been practicable to measure the flow of water into and from this reservoir during the time the experiments were made, though notes were kept of the changes in the height of water, and approximate measurements of the flow of the stream have been made during a portion of the time. An approximate estimate of the quantity of water flowing through the reservoir in different months can be made by applying the record of flow of the Sudbury River; and for convenience the monthly flow of that stream during the years 1903, 1904 and 1905 is appended. The quantity of water which passed through the reservoir in the winter of 1904–05 was enough to change the water more than three times. The daily rainfall records at the Chestnut Hill pumping station of the metropolitan water works, distant about 7 miles from the reservoir, for the period covered by the experiments are also appended.

Chemical Examinations of Water from Arlington Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1905.																
-	Jan. 9	-	-	.60	- -	- -	5.70	2.30	.0108	.0284	.0226	.0058	.58	.0290	.0002	0.78	2.1
52985	Feb. 20	V. slight.	V. slight, cons., crustaceæ.	.60	Faintly unpleasant.	Faintly unpleasant.	7.95	3.15	.0166	.0232	.0216	.0016	.74	.0600	.0003	0.70	2.9
53335	Mar. 20	Decided.	V. slight.	.72	Faintly unpleasant.	Distinctly unpleasant.	6.05	2.50	.0272	.0408	.0232	.0176	.44	.0240	.0005	1.08	1.8
53770	Apr. 17	Slight, green.	Cons., green.	.66	Faintly vegetable, organisms.	Decidedly vegetable, organisms.	6.45	2.70	.0028	.0400	.0268	.0132	.56	.0270	.0003	0.77	1.8
53803	Apr. 20	Decided, green.	Cons., green.	.64	Distinctly unpleasant, organisms.	Decidedly unpleasant, organisms.	6.25	2.50	.0040	.0432	.0272	.0160	.57	.0190	.0003	0.74	2.1
53920	May 1	Decided, green.	Cons., green.	.65	Faintly vegetable and sweetish.	Distinctly vegetable and sweetish.	5.55	2.00	.0032	.0388	.0232	.0156	.58	.0110	.0003	0.88	2.1
54183	May 15	Decided, green.	Cons., green.	.64	V. faintly unpleasant.	Faintly unpleasant.	5.85	2.15	.0014	.0480	.0290	.0190	.63	.0030	.0001	0.78	1.8
54404	May 29	Decided, green.	Cons., green.	.56	Faintly unpleasant, decaying organisms.	Distinctly unpleasant, decaying organisms.	6.20	2.20	.0036	.0408	.0300	.0108	.65	.0020	.0000	0.78	2.2
54661	June 12	Decided.	Cons.	.70[1]	Distinctly vegetable, decaying organisms.	Decidedly vegetable, decaying organisms.	6.70	2.80	.0036	.0608	.0408	.0200	.68	.0040	.0001	0.79	2.5
54910	June 23	Decided, green.	Cons., green.	.67	Faintly vegetable and unpleasant.	Distinctly vegetable and unpleasant.	6.85	2.80	.0030	.0525	.0355	.0170	.66	.0040	.0003	0.81	2.2
54930	June 26	Decided, green.	Cons., green.	.70	Distinctly vegetable and unpleasant, decaying organisms.	Distinctly vegetable and unpleasant, decaying organisms.	6.75	2.90	.0050	.0565	.0375	.0190	.64	.0080	.0001	0.76	2.2
55185	July 10	Slight.	Cons., green.	.58	Distinctly unpleasant, decaying organisms.	Distinctly unpleasant, decaying organisms.	7.20	2.85	.0016	.0436	.0328	.0108	.66	.0010	.0000	0.86	2.1
55464	July 24	Decided, green.	Cons., green.	.53	Distinctly unpleasant and vegetable.	Distinctly unpleasant and vegetable.	7.20	3.20	.0015	.0495	.0270	.0225	.74	.0040	.0001	0.78	2.3
55805	Aug. 7	Slight.	Cons., organisms.	.41	V. faintly unpleasant.	Distinctly unpleasant, organisms.	6.85	3.60	.0005	.0430	.0295	.0135	.76	.0020	.0002	0.72	2.3

[1] Filtered.

Chemical Examinations of Water from Arlington Reservoir — Concluded.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1905.																
56199	Aug. 21	Slight.	Cons.	.35	Distinctly sweetish, organisms.	Distinctly sweetish, organisms.	7.20	3.25	.0060	.0395	.0250	.0145	.78	.0040	.0000	0.60	2.5
-	Sept. 1	-	-	.30	- -	- -	6.82	2.97	.0000	.0552	.0312	.0240	.75	.0000	.0000	0.63	2.5
56499	Sept. 5	Decided, green.	Cons., green.	.54	Distinctly vegetable, organisms.[1]	Distinctly vegetable and unpleasant, organisms.[1]	6.65	2.45	.0060	.0560	.0345	.0215	.65	.0070	.0002	0.80	2.3
56816	Sept. 18	Decided, green.	Cons., green.	.59	Distinctly vegetable and earthy.[1]	Decidedly vegetable and earthy, organisms.[1]	7.75	3.45	.0028	.0532	.0360	.0172	.67	.0010	.0000	0.84	2.6
57146	Oct. 2	Slight, green.	Cons., green.	.51	Distinctly vegetable and unpleasant.[1]	Decidedly vegetable and unpleasant.[1]	7.75	3.00	.0048	.0496	.0352	.0144	.66	.0050	.0001	0.87	2.5
57494	Oct. 16	Decided, green.	Cons., green.	.44	Distinctly vegetable and grassy.	Decidedly vegetable and grassy.	7.10	2.75	.0045	.0480	.0295	.0185	.68	.0010	.0000	0.72	2.5
57735	Oct. 30	Decided, green.	Cons., green.	.35	Faintly vegetable and grassy.	Distinctly vegetable and grassy.	7.05	2.75	.0044	.0472	.0288	.0184	.70	.0020	.0000	0.66	2.7
58070	Nov. 13	Decided.	Cons.	.36	Distinctly vegetable.	Distinctly vegetable.	7.05	2.35	.0026	.0322	.0252	.0070	.69	.0030	.0001	0.56	2.2

[1] *Anabæna.*

Arlington Reservoir.— Table showing Number of Principal Organisms per Cubic Centimeter.

	1905.														
	January 9.	February 20.	March 20.	April 13.	April 17.	April 20.	May 1.	May 15.	May 24.	May 29.	June 1.	June 12.	June 23.	June 26.	July 10.
Days after last treatment,	132	174	202	226	230	233	244	258	267	272	275	286	297	300	314
Number of samples,	2	1	1	2	1	1	1	3	1	1	2	1	1	1	1
Diatomaceæ:—															
Asterionella,	26	0	0	14	96	228	88	67	20	0	0	0	0	0	0
Cyclotella,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fragilaria,	0	0	0	21	38	0	0	213	0	880	45	0	0	0	0
Melosira,	0	0	0	101	160	140	736	413	260	80	75	0	32	0	0
Synedra,	*	0	0	111	260	308	3,376	11,780	23,000	544	2,170	360	192	40	7,016
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Anabæna,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphanizomenon,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algæ:—															
Cosmarium,	0	0	0	0	0	8	16	40	140	0	60	100	160	256	32
Protococcus,	0	0	0	36	92	532	1,168	307	0	80	30	40	0	0	560
Scenedesmus,	12	0	0	234	544	1,104	1,712	2,893	2,240	1,900	3,110	2,640	3,568	3,088	448
Staurastrum,	0	0	0	0	2	8	0	113	40	20	60	60	8	40	1,752
Infusoria,	**9**	**10**	**11**	**28**	**42**	**8**	**32**	**8**	**0**	**0**	**25**	**0**	**0**	**0**	**0**
Monas,	0	0	0	15	24	4	16	0	0	0	0	0	0	0	0
Total organisms,	52	11	19	737	1,280	2,414	7,532	16,240	26,105	8,525	5,625	3,355	4,350	3,772	9,810

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Arlington Reservoir. — Table showing Number of Principal Organisms per Cubic Centimeter — Concluded.

	1905.													
	July 13.	July 17.	July 23.	July 26.	August 2.	August 7.	August 21.	September 1.	September 5.	September 15.	September 18.	October 2.	October 16.	October 30.
Days after last treatment,	317	321	327	330	337	342	356	367	371	381	384	398	412	426
Number of samples,	2	2	1	2	2	1	1	2	1	2	1	1	1	1
Diatomaceæ:—														
Asterionella,	0	20	16	0	60	0	0	0	0	20	16	40	384	172
Cyclotella,	0	0	0	0	0	0	0	0	16	0	0	8	0	0
Fragilaria,	0	20	0	80	0	0	0	0	56	24	48	0	0	0
Melosira,	0	0	0	80	0	0	0	332	96	232	192	64	152	484
Synedra,	3,580	2,896	2,144	1,370	1,864	864	48	76	40	152	8	0	16	216
Cyanophyceæ,	**0**	**0**	**72**	**0**	**8**	**10**	**248**	**580**	**456**	**545**	**472**	**184**	**32**	**20**
Anabæna,	0	0	16	0	0	0	24	120	136	68	88	24	28	12
Aphanizomenon,	0	0	56	0	0	8	208	432	264	468	368	160	0	8
Chroöcoccus,	0	0	0	0	0	0	16	28	56	8	16	0	0	0
Cœlosphærium,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algæ:—														
Cosmarium,	32	41	88	82	232	112	704	488	144	0	0	56	0	0
Protococcus,	252	428	352	527	736	1,144	688	474	200	0	0	432	324	248
Scenedesmus,	320	298	1,072	1,115	1,780	800	736	956	632	1,296	1,368	912	3,320	2,236
Staurastrum,	2,840	3,856	4,768	3,915	72	112	224	84	72	192	288	128	140	84
Infusoria,	**0**	**0**	**32**	**12**	**8**	**0**	**24**	**48**[1]	**8**	**48**[1]	**88**	**120**	**92**	**20**
Monas,	0	0	0	0	0	0	0	4	0	0	0	0	0	0
Total organisms,	7,026	7,577	8,548	7,225	4,766	3,054	2,732	3,407	1,896	3,031	3,060	1,970	4,486	3,534

[1] Essentially *Trachelomonas*.

Arlington Reservoir. — Table showing Results of Copper Analyses.

[Unless otherwise stated, the samples examined were made up of several samples collected from different parts of the reservoir.]

Date.	Location.	Days after Last Treatment.	Water.			Mud.	
			Quantity examined (Litres).	Parts Copper Sulphate to 100,000 Parts Water.	Million Parts Water to 1 Part Copper Sulphate.	Quantity examined, Dry (Grams).	Parts Copper Sulphate to 100,000 Parts Dry Mud.
1904.							
July 12,	–	–	15	.00000	*	100	2.36
28,	Treatment: 1 part copper sulphate to 3,650,000 parts water.						
Aug. 5,	–	8	50	.02277	4.40	–	–
9,	–	12	50	.02042	4.90	–	–
10,	Additional treatment: 1 part copper sulphate to 730,000 parts water.						
11,	–	1	–	–	0.89	–	–
12,	–	2	35	.18173	0.55	–	–
13,	–	3	25	.21672	0.46	50	81.66
15,	–	5	35	.13462	0.74	100	47.90
17,	–	7	30	.10600	0.94	–	–
19,	–	9	30	.10078	0.99	25	86.37
22,	–	12	30	.14133	0.71	100	141.34
25,	–	15	30	.06937	1.40	25	102.08
26,	Overflow,	16	20	.05693	1.80	–	–
27,	–	17	–	.10600	0.94	25	163.32
29,	–	19	30	.04056	2.50	–	–
30,	Additional treatment: 1 part copper sulphate to 730,000 parts water.						
31,	–	1	15	.14133	0.71	25	160.18
Sept. 2,	–	3	15	.15178	0.66	25	133.48
6,	–	7	35	.11209	0.89	25	186.88
8,	–	9	30	.05756	1.70	–	–
12,	–	13	25	.06125	1.60	–	–
15,	–	16	30	.04841	2.10	–	–
16,	–	17	–	–	–	10	164.89
17,	–	18	30	.03663	2.70	–	–
21,	–	22	30	.03533	2.80	10	117.78
23,	–	24	45	.02356	4.20	10	168.82
27,	–	28	45	.02878	3.50	10	314.08
Oct. 1,	–	32	–	–	–	10	188.45
7,	–	38	50	.01335	7.50	10	451.49
Nov. 3,	–	65	50	.00942	11.00	10	180.60
	Inlet,	65	50	.00000	*	–	–
Dec. 14,	–	106	50	.00864	11.60	–	–

* No copper present.

Arlington Reservoir. — Table showing Results of Copper Analyses — Concluded.

[Unless otherwise stated, the samples examined were made up of several samples collected from different parts of the reservoir.]

Date.	Location.	Days after Last Treatment.	Water.			Mud.	
			Quantity examined (Litres).	Parts Copper Sulphate to 100,000 Parts Water.	Million Parts Water to 1 Part Copper Sulphate.	Quantity examined, Dry (Grams).	Parts Copper Sulphate to 100,000 Parts Dry Mud.
1905.							
Jan. 9,	-	132	50	.00314	32.00	10	137.41
	Inlet,	132	50	.01413	7.10	-	-
Feb. 15,	Water,	169	45	.00263	38.00	-	-
	Ice,	169	40	.00294	34.00	-	-
April 20,	Surface,	233	50	.00393	25.00	-	-
	Bottom,	233	50	.00471	21.00	-	-
May 22,	Surface,	265	50	.00393	25.00	-	-
	Bottom,	265	50	.00393	25.00	-	-
June 23,	-	297	50	.00471	21.00	-	-
	Overflow,	297	50	.00471	21.00	-	-
Sept. 1,	-	367	50	.00471	21.00	-	-
Oct. 3,	-	399	50	.00471	21.00	-	-

Table showing the Yield of the Sudbury River Water-shed in Gallons per Square Mile per Day.

Month.	1903.	1904.	1905.
January,	1,736,000	477,000	1,410,000
February,	2,279,000	882,000	330,000
March,	3,454,000	2,999,000	2,497,000
April,	2,261,000	3,294,000	1,643,000
May,	351,000	1,745,000	297,000
June,	1,987,000	419,000	467,000
July,	445,000	62,000	177,000
August,	307,000	170,000	114,000
September,	130,000	397,000	1,246,000
October,	492,000	191,000	158,000
November,	363,000	289,000	279,000
December,	582,000	269,000	887,000

Daily Rainfall in Inches at Chestnut Hill during the Period of Experiments upon the Use of Copper Sulphate.

[Asterisk indicates precipitation included in that of following day.]

Day of Month.	1904.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	–	–	0.21	1.01	–	–	0.02	*	trace	trace	–	–
2,	*	–	–	–	–	0.57	–	0.88	trace	–	–	–
3,	1.15	–	0.47	–	–	–	–	0.08	–	–	–	–
4,	–	–	–	–	–	–	–	–	0.02	–	–	–
5,	–	–	trace	–	–	trace	0.44	–	–	0.32	–	0.21
6,	–	0.40	–	–	–	trace	–	0.19	–	trace	–	–
7,	–	–	*	0.17	–	0.50	–	–	–	–	–	–
8,	*	–	0.96	–	–	0.05	–	0.03	*	trace	–	0.06
9,	1.09	–	–	0.49	0.79	–	–	–	0.16	0.02	trace	–
10,	–	–	–	0.93	0.14	–	trace	*	0.12	–	–	trace
11,	–	–	trace	0.06	–	–	–	0.41	0.43	0.14	–	–
12,	0.03	–	–	0.32	–	–	–	–	0.08	*	–	trace
13,	1.18	–	–	–	–	–	0.09	–	–	0.92	*	0.15
14,	–	*	–	trace	–	–	–	0.08	*	–	1.66	–
15,	–	0.77	0.14	–	0.24	–	–	–	3.84	–	–	–
16,	0.09	–	–	0.38	–	–	–	0.04	–	–	trace	trace
17,	–	–	–	–	–	–	0.19	–	–	–	–	–
18,	–	–	0.40	–	0.68	–	–	–	–	–	–	0.71
19,	–	0.21	trace	0.25	0.38	–	–	–	–	–	–	–
20,	0.08	–	0.07	trace	0.09	–	–	*	trace	–	–	trace
21,	*	–	–	–	–	0.20	–	1.03	–	0.64	0.05	–
22,	1.04	0.98	*	–	–	0.07	–	–	–	–	–	trace
23,	0.10	–	0.27	–	–	0.03	0.32	–	–	–	–	trace
24,	–	0.33	–	0.10	–	–	0.21	–	trace	–	–	–
25,	–	–	–	–	0.28	0.30	0.08	–	0.18	–	–	–
26,	0.73	–	–	–	–	0.18	–	–	0.12	0.17	–	0.06
27,	–	–	–	0.10	0.40	–	0.06	–	–	–	trace	*
28,	–	0.15	trace	*	–	–	–	–	–	–	–	1.62
29,	0.15	–	–	*	–	0.53	0.07	–	0.77	–	*	–
30,	–	–	–	5.37	0.28	0.32	–	–	0.03	–	0.10	–
31,	–	–	0.20	–	–	–	–	–	–	–	–	–
Totals,	5.64	2.84	2.72	9.18	3.28	2.75	1.48	2.74	5.75	2.21	1.81	2.81

Daily Rainfall in Inches at Chestnut Hill, etc. — Concluded.

[Asterisk indicates precipitation included in that of following day.]

Day of Month.	1905.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	-	-	-	-	-	-	-	0.39	-	-	-	-
2,	*	-	-	-	-	0.02	0.02	0.07	*	-	-	-
3,	*	-	-	-	-	-	0.29	0.09	*	0.07	-	-
4,	1.47	-	0.05	trace	-	-	-	-	5.24	-	0.81	-
5,	-	-	-	0.22	-	-	-	-	-	-	-	-
6,	*	*	-	1.52	0.04	0.51	-	-	0.20	-	*	-
7,	1.88	1.05	*	-	0.04	trace	-	-	-	-	0.33	-
8,	-	-	0.91	-	-	0.68	-	-	-	-	-	-
9,	-	0.26	0.40	-	0.07	-	-	0.15	-	-	-	-
10,	-	0.34	-	-	-	-	0.04	-	-	-	-	-
11,	-	-	-	0.70	-	trace	-	-	*	*	-	-
12,	0.08	0.56	-	0.12	0.04	*	-	1.06	*	0.30	-	-
13,	0.52	trace	-	-	0.02	1.60	-	-	0.24	-	trace	-
14,	-	-	-	-	0.16	-	0.82	-	-	-	-	-
15,	-	-	-	-	0.14	-	-	0.62	-	-	*	-
16,	-	-	-	-	-	-	0.06	0.18	-	-	0.08	-
17,	-	-	-	-	-	-	0.02	-	trace	-	-	-
18,	-	-	-	-	0.37	-	-	-	*	-	-	-
19,	-	-	0.24	-	0.62	*	0.04	-	0.25	trace	-	-
20,	-	0.06	0.03	trace	-	*	-	-	-	*	-	-
21,	*	-	*	0.05	-	1.54	-	-	-	*	-	-
22,	0.15	-	1.04	0.45	-	0.46	-	0.22	-	1.14	-	-
23,	-	-	-	-	-	-	-	-	-	-	-	-
24,	*	-	-	-	-	-	-	trace	-	trace	*	-
25,	1.32	-	0.16	-	-	-	-	0.29	-	0.02	0.03	-
26,	-	-	0.37	-	-	0.33	-	-	-	-	-	-
27,	-	-	-	-	-	0.08	-	0.19	-	-	-	-
28,	0.07	-	0.04	-	-	0.14	-	-	-	-	*	-
29,	-	-	-	0.02	-	0.02	0.16	0.11	-	-	1.26	-
30,	-	-	0.10	-	0.15	-	0.10	0.44	-	-	-	-
31,	-	-	-	-	-	-	0.39	0.03	-	-	-	-
Totals,	5.49	2.27	3.34	3.08	1.65	5.38	1.94	3.84	5.93	1.53	2.51	-

Belchertown Reservoir.

Belchertown Reservoir was formerly a tributary of the Broad Brook Canal, the main feeder of Ludlow Reservoir, the principal source of water supply of the city of Springfield. It was originally constructed for mill purposes many years before it was used as a source of water supply. It was first used for water-supply purposes in 1875, but, owing to the very objectionable quality of its water, its use was abandoned in 1886.

A recent survey by the Springfield water department shows that its area is about 35 acres and its storage capacity about 56,000,000 gallons. Its maximum depth is about 7 feet, its general depth 4 to 5 feet, and the bottom is covered with mud. There are large growths of lilies and other water plants about the shores and in the shallow portions; and an extensive swamp borders the brook at the upper end of and above the reservoir, containing great quantities of bushes, water weeds and organic matter of various kinds. The water-shed, of about 2.9 square miles,[1] consists largely of swamp, and, in consequence of these conditions, the water of the reservoir is highly colored and contains a large quantity of organic matter. The chief characteristic of the water has been the presence in the summer season of the organism *Anabœna,* which has appeared annually in great numbers.

The first treatment of this reservoir for the removal of objectionable organic growths by the use of copper sulphate was made on July 21, 1904. Microscopical analyses had shown, on July 14, the presence of *Anabœna* in very large numbers which increased very rapidly, until, on July 20, the filaments numbered approximately 1,200 per cubic centimeter. On July 21, 58 pounds of copper sulphate were applied, a quantity equivalent to 1 part in 8,000,000 parts of water. The treatment was made under the direction of Mr. Karl F. Kellerman of the United States Department of Agriculture, assisted by Mr. Mead and by Mr. E. E. Lochridge, the engineer of the Springfield water department. The copper sulphate was applied in the usual manner, by trailing it in a burlap sack at the stern of a boat while rowing about the main portion of the reservoir. The swampy area at the upper end of the reservoir was inaccessible, and copper could not be applied in this portion. The greater portion of this swamp, however, is separated from the reservoir by a dike, through which there is an opening where the brook enters the reservoir. In order to treat the water entering the reservoir from the brook, a bag containing 30 pounds of copper sulphate was suspended in the water

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[1] After July, 1905, the area of the water-shed was 1.2 square miles. (See note on page 248.)

from the bridge, where it slowly dissolved. The flow into the reservoir at this time was very small.

Immediately following this treatment the numbers of *Anabæna* rapidly diminished, and had practically disappeared from the water on July 27, six days after the copper sulphate was applied. A few Cyanophyceæ were present during the remainder of the year, but in insignificant numbers. The other organisms also diminished in numbers immediately after the application of the copper sulphate, until, on July 25, four days after the copper sulphate was applied, the total number of organisms present had fallen to about 200 per cubic centimeter. From this time, however, a rapid increase in the number took place, until a maximum of about 5,000 was reached on September 26, the principal organisms present at this time being two of the Diatomaceæ, — *Asterionella* and *Tabellaria.*

Chemical analyses of the water showed a marked reduction in the quantity of organic matter present after the application of the copper sulphate on July 21, and, notwithstanding the increase in the growths of other organisms after the disappearance of *Anabæna,* the organic matter as shown by the albuminoid ammonia continued to decrease gradually until the examinations were discontinued, in November.

Samples of the water of the reservoir and of mud from its bottom were collected before copper sulphate was applied, and analyzed to determine the quantity of copper present. The results showed that there was present in the water an amount equivalent to 1 part of copper sulphate to 64,000,000 parts of water, and in the mud a quantity equivalent to 4.46 parts of copper sulphate in 100,000 parts of dry mud. After the treatment the quantity of copper present both in the water and in the mud fluctuated greatly from time to time; but, on the whole, the quantity in the mud increased decidedly, while the quantity present in the water gradually decreased.

In the year 1905 the examinations of the reservoir water were begun on May 9, when the organism *Anabæna* was found to be present in considerable numbers. A week later the numbers had become very large, and the quantity of organic matter present in the water had become much greater than at the end of the previous year. The condition of the water continued to grow worse until June 13, when copper sulphate was applied in a quantity equivalent to 1 part in 8,000,000 parts of water, — the same quantity as was used in the previous year.

The conditions at the reservoir in 1905 were somewhat different from those existing in the previous year, since the Springfield water department had found it desirable to lower the water level in the swamp above the reservoir; and, for this purpose, the water in the reservoir was kept at a considerably lower level than in 1904.

The quantity of copper sulphate applied in 1904 was 58 pounds to the reservoir itself, while 30 pounds were suspended in a bag in the water at the point where the brook enters the reservoir. On account of the smaller quantity of water, the quantity of copper sulphate applied on June 13, 1905, was only 35 pounds, and no copper sulphate was placed at the point where the brook enters the reservoir.

At the time this treatment was made, — June 13, 1905, — beside *Anabœna,* large numbers of the Diatomaceæ, *Asterionella* and *Melosira,* were present in the water, and considerable numbers of *Tabellaria,* while the green Alga, *Scenedesmus,* was also present in notable numbers. After the application of the copper sulphate the numbers of all of these organisms diminished rapidly during the first three days, and the number of *Anabœna* continued to diminish, until, on June 26, thirteen days after the treatment, the number had fallen from 644 per cubic centimeter to 12. From this time, however, the numbers increased rapidly to July 10, when the number was 278 per cubic centimeter, and then very rapidly until July 18, when the number was much greater than the number present on June 13, at the time of the treatment.

The number of *Asterionella,* as already noted, fell off for the first few days after the copper sulphate was applied to the reservoir (June 13) but subsequently increased, until, on the 20th, a week after the treatment, the number was about as great as on the 13th. The number then rapidly diminished until it became insignificant on July 18. *Tabellaria* also increased somewhat after the treatment, and then gradually disappeared. *Melosira,* on the other hand, decreased for a few days and then increased very rapidly until June 19, when the number was more than twice as great as before the copper sulphate was applied. The number of these organisms continued high until July 11, and then diminished.

As already stated, *Scenedesmus* was present in notable numbers before copper sulphate was applied on June 13. From this time the number increased rapidly up to June 26 and then fell off again, but was still large at the time of the next treatment.

On July 18 the condition of the water was worse than at any time in this or the previous year, and on this date copper sulphate was again applied, in a quantity equivalent to 1 part in 8,000,000 parts of water, this treatment requiring the same quantity of copper sulphate as was used at the previous time.

Following this treatment, *Anabœna* rapidly diminished in numbers, and none was found in the water after August 4. The other organisms showed a tendency to increase in the same manner as in the previous year; but the water was gradually drawn out of the reservoir, so that the results are not comparable with those of 1904. The quantity

of organic matter in the water up to the end of September remained much higher than in the previous year.

After the first application of copper sulphate to this reservoir, on July 21, 1904, three fish of the kind known as suckers were found dead in the water of the reservoir; but doubt was expressed by the observers as to whether these fish were killed by the copper sulphate. With these exceptions, the fish were not apparently affected by either of the applications of copper sulphate.

Tables of the results of chemical and microscopical analyses are appended, together with a table showing the rainfall at Amherst, about 11 miles from Belchertown Reservoir, in the years 1904 and 1905. A table is also appended showing the approximate flow from the water-shed of Belchertown Reservoir, obtained by applying the rate of flow per square mile of water-shed found in the neighboring water-shed of Jabish Brook, this stream having been measured during the period covered by the experiments.

Chemical Examinations of Water from Belchertown Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1904.																
50172	July 14	Decided, green.	Cons., vegetable matter.	1.24	Decided, grassy.[1]	Decided, corn silk.[1]	4.75	2.95	.0140	.0780	.0375	.0405	.12	.0020	.0000	1.28	1.1
–	July 20	–	–	1.00	– –	– –	4.68	2.73	.0022	.1060	.0408	.0652	.14	.0010	.0000	1.22	1.1
50309	July 21	Slight.	Cons.	0.80	Faintly vegetable.	Faintly vegetable.	4.55	2.25	.0060	.0330	.0295	.0035	.16	.0030	.0000	0.88	1.3
–	July 22	–	–	1.07	– –	– –	5.06	2.93	.0109	.0891	.0486	.0405	.13	.0030	.0000	1.23	1.3
–	July 25	–	–	0.96	– –	– –	5.10	3.00	.0375	.0692	.0502	.0190	.13	.0025	.0000	1.24	1.6
–	July 27	–	–	0.98	– –	– –	4.35	2.57	.0347	.0585	.0452	.0133	.11	.0020	.0001	1.08	1.3
–	July 29	–	–	1.00	– –	– –	4.82	2.75	.0440	.0552	.0416	.0136	.12	.0110	.0001	1.14	1.4
–	Aug. 2	–	–	0.92	– –	– –	4.50	2.62	.0130	.0706	.0522	.0184	.11	.0025	.0000	1.06	1.1
–	Aug. 4	–	–	0.95	– –	– –	4.30	2.27	.0048	.0568	.0402	.0166	.11	.0005	.0000	1.04	1.0
–	Aug. 12	–	–	0.84	– –	– –	4.10	2.17	.0055	.0450	.0320	.0130	.13	.0000	.0000	0.92	1.2
–	Aug. 18	–	–	0.88	– –	– –	4.00	2.12	.0025	.0520	.0450	.0070	.13	.0025	.0001	0.94	1.2
–	Aug. 23	–	–	0.76	– –	– –	4.35	2.35	.0022	.0464	.0330	.0134	.15	.0015	.0000	0.94	1.0
–	Aug. 26	–	–	0.79	– –	– –	3.87	2.52	.0034	.0405	.0257	.0148	.16	.0020	.0000	0.97	1.1
–	Aug. 31	–	–	0.81	– –	– –	4.02	2.20	.0037	.0492	.0330	.0162	.18	.0010	.0001	1.02	1.0
–	Sept. 2	–	–	0.75	– –	– –	4.15	2.37	.0052	.0380	.0280	.0100	.15	.0040	.0001	0.98	1.0
–	Sept. 12	–	–	0.67	– –	– –	3.87	2.15	.0010	.0430	.0310	.0120	.17	.0010	.0003	0.96	1.0

Anabæna.

Chemical Examinations of Water from Belchertown Reservoir — Concluded.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1904.																
-	Sept. 19	-	-	0.78	- -	- -	4.02	2.22	.0022	.0346	.0250	.0096	.17	.0005	.0000	1.22	1.0
-	Sept. 26	-	-	1.03	- -	- -	4.45	2.40	.0012	.0396	.0310	.0086	.15	.0000	.0001	1.18	1.1
-	Oct. 4	-	-	1.04	- -	- -	4.17	2.32	.0025	.0397	.0295	.0102	.17	.0010	.0000	1.19	1.2
52035	Nov. 9	Slight.	Cons.	0.68	V. faintly vegetable.	Distinctly vegetable.	4.25	2.15	.0040	.0315	.0255	.0060	.21	.0030	.0000	0.90	1.3
	1905.																
54076	May 9	Slight.	Cons., also scum.	0.86	Faintly vegetable and unpleasant.	Distinctly vegetable and unpleasant.	4.15	2.15	.0048	.0372	.0240	.0132	.15	.0030	.0000	1.08	0.6
54215	May 16	Decided.	Cons., also scum of organisms.	0.92	Faintly vegetable and unpleasant.[1]	Distinct of corn silk.[1]	3.70	1.90	.0045	.0500	.0310	.0190	.15	.0010	.0000	1.04	0.8
54334	May 22	Decided, green.	Cons., green.	0.92	Distinctly grassy and corn silk.[1]	Decidedly grassy and corn silk.[1]	3.85	2.20	.0030	.0550	.0315	.0235	.13	.0000	.0000	1.08	0.8
54447	May 31	Decided.	Cons., also scum.	0.85	Decided corn silk.[1]	Decided corn silk.[1]	3.55	1.70	.0070	.0645	.0310	.0335	.14	.0010	.0000	0.98	1.1
-	June 13	-	-	0.91	- -	- -	4.15	2.30	.0150	.0770	.0360	.0410	.14	.0070	.0001	0.83	0.6
-	June 15	-	-	0.88	- -	- -	4.27	2.47	.0220	.0825	.0470	.0355	.14	.0030	.0002	0.86	1.1
-	June 16	-	-	0.90	- -	- -	4.20	2.28	.0506	.0604	.0420	.0184	.13	.0015	.0001	0.81	1.0
-	June 17	-	-	0.88	- -	- -	4.45	2.55	.0460	.0590	.0392	.0198	.13	.0020	.0001	0.82	1.1
-	June 18	-	-	0.91	- -	- -	4.57	2.07	.0352	.0725	.0430	.0295	.13	.0035	.0001	0.84	1.0
-	June 19	-	-	1.05	- -	- -	4.77	2.25	.0320	.0992	.0432	.0560	.13	.0025	.0001	0.84	1.0
-	June 20	-	-	0.93	- -	- -	4.38	2.55	.0202	.0727	.0443	.0284	.14	.0040	.0003	0.86	1.1
-	June 26	-	-	0.99	- -	- -	4.75	2.62	.0027	.0605	.0342	.0263	.12	.0010	.0000	1.17	1.2

54974	June 27	Decided, green.	Cons., green.	0.95	Faintly vegetable and musty, decaying Anabæna.	Distinctly vegetable and musty, decaying Anabæna.	4.90	2.55	.0015	.0450	.0330	.0120	.12	.0020	.0000	1.06	1.1
–	July 10	–	–	0.86	– –	– –	4.50	2.35	.0030	.0922	.0385	.0537	.14	.0035	.0001	0.88	1.4
55228	July 11	Decided, green.	Cons., also scum.	0.80	Distinctly unpleasant.[1]	Distinct of corn silk.[1]	4.25	2.10	.0022	.0800	.0310	.0490	.15	.0010	.0000	0.76	1.3
–	July 18	–	–	1.35	– –[1]	– –[1]	5.15	2.72	.0157	.1400	.0505	.0895	.15	.0020	.0001	1.07	0.9
–	July 19	–	–	1.43	– –[1]	– –[1]	5.72	3.02	.0125	.1190	.0630	.0560	.14	.0030	.0002	1.17	0.8
–	July 22	–	–	1.55	– –[1]	– –[1]	5.62	3.00	.0020	.1300	.0615	.0685	.15	.0055	.0001	1.14	1.0
–	July 24	–	–	1.37	– –[1]	– –[1]	5.42	2.67	.0325	.0732	.0412	.0320	.14	.0030	.0001	1.04	1.0
55592	July 25	Decided.	Cons.	1.50	Faintly vegetable and unpleasant.	Distinctly vegetable and unpleasant.	5.50	2.80	.0148	.0756	.0656	.0100	.14	.0010	.0001	0.98	1.1
55633	July 28	Slight.	Cons.	1.20	– –	– –	5.37	2.70	.0010	.0820	.0522	.0298	.15	.0010	.0001	0.96	0.9
55737	Aug. 2	V. slight.	Slight.	1.28	Faintly unpleasant.	Distinctly unpleasant, decaying organisms.	4.95	2.45	.0140	.0524	.0400	.0124	.14	.0050	.0002	0.90	1.0
–	Aug. 4	–	–	1.17	– –	– –	4.82	2.32	.0040	.0660	.0407	.0253	.15	.0010	.0001	0.92	1.0
55870	Aug. 8	Slight.	Cons.	1.24	Faintly vegetable.	Distinctly unpleasant, organisms.	5.00	2.50	.0030	.0475	.0390	.0085	.14	.0010	.0003	1.00	1.0
56234	Aug. 22	Slight.	Cons.	1.16	Faintly unpleasant, organisms.	Distinctly unpleasant, organisms.	5.25	2.30	.0055	.0695	.0410	.0285	.16	.0020	.0000	0.90	1.0
–	Aug. 29	–	–	1.30	– –	– –	5.10	2.47	.0065	.0580	.0465	.0115	.14	.0040	.0000	1.03	0.9
56664	Sept. 12	Slight.	Cons.	1.10	Distinctly vegetable.	Decidedly vegetable.	5.30	2.80	.0044	.0372	.0300	.0072	.13	.0050	.0001	1.36	1.4
56859	Sept. 19	Slight.	Cons.	0.90	Distinctly vegetable and unpleasant.	Distinctly vegetable and unpleasant.	4.90	2.30	.0044	.0392	.0268	.0124	.14	.0010	.0000	0.94	1.3
56992	Sept. 26	Slight.	Cons.	0.93	Distinctly vegetable.	Distinctly vegetable.	5.00	2.20	.0008	.0372	.0264	.0108	.14	.0010	.0000	0.84	1.0
–	Sept. 27	–	–	0.84	– –	– –	5.05	2.30	.0020	.0358	.0259	.0099	.14	.0030	.0000	0.88	1.3
57654	Oct. 24	Decided.	Cons.	0.53	Distinctly cucumber.[2]	Distinctly cucumber.[2]	3.50	1.45	.0036	.0252	.0190	.0062	.16	.0010	.0001	0.58	0.8
57821	Nov. 1	V. slight.	V. slight.	0.42	Distinctly cucumber.[2]	Distinctly cucumber.[2]	4.30	1.55	.0026	.0196	.0162	.0034	.14	.0020	.0000	0.42	0.8
57960	Nov. 7	Slight.	Slight.	0.38	Faintly vegetable and unpleasant.	Faintly vegetable and unpleasant.	3.70	1.50	.0044	.0184	.0144	.0040	.16	.0010	.0001	0.44	1.6
57961	Nov. 8	Decided.	Heavy, earthy.	0.52	Distinctly vegetable and musty.	Distinctly vegetable and musty.	5.05	1.85	.0410	.1810	.0170	.1640	.18	.0030	.0001	0.64	1.7
58184	Nov. 15	Decided, earthy.	Cons., earthy.	0.31	Faintly unpleasant and earthy.	Distinctly unpleasant and earthy.	5.20	1.50	.0315	.0490	.0095	.0395	.14	.0070	.0001	0.35	1.4
58242	Nov. 21	Slight.	Cons., earthy.	0.23	V. faintly vegetable and earthy.	Faintly vegetable and earthy.	5.50	1.25	.0310	.0525	.0086	.0439	.13	.0060	.0001	0.26	1.4

[1] *Anabæna*. [2] *Synura*.

Belchertown Reservoir, Springfield.— Table showing Number of Principal Organisms per Cubic Centimeter.

	1903.	1904.													
	September 17.	July 14.	July 20.	July 21.	July 21.	July 22.	July 24.	July 25.	July 27.	July 29.	August 2.	August 4.	August 12.	August 18.	August 23.
Days after last treatment,	-	-	-	-	-	1	3	4	6	8	12	14	22	28	33
Number of samples,	1	1	12	-	6	12	2	8	2	2	2	2	2	5	4
Diatomaceæ:—				Treatment: 1 part copper sulphate to 8,000,000 parts water. Resulting concentration: 1:6,400,000.											
Asterionella,	51	152	32		15	12	18	15	50	44	56	16	264	386	458
Melosira,	24	52	60		0	30	40	16	5	40	200	26	124	61	119
Synedra,	0	4	2		4	2	2	2	4	0	0	0	0	13	22
Tabellaria,	0	448	93		92	52	38	41	74	32	188	184	292	576	842
Cyanophyceæ,	**52**	**916**	**1,222**		**915**	**267**	**24**	**5**	**1**	**0**	**1**	**2**	**1**	**6**	**2**
Anabæna,	51	916	1,195		908	266	22	5	1	0	0	0	0	*	0
Algæ:—															
Polyedrium,	5	0	0		0	0	0	0	0	6	26	44	62	158	185
Scenedesmus,	16	16	27		5	7	8	3	28	96	200	176	204	174	134
Infusoria,	**47**	**4**	**19**		**18**	**19**	**8**	**26**	**117**	**76**	**223**	**50**	**265**	**419**	**127**
Dinobryon,	2	0	0		1	2	0	0	0	0	14	0	184	302	47
Uroglena,	1	0	3		0	0	0	0	0	0	0	0	0	0	0
Total organisms,	245	1,614	1,591		1,139	480	368	203	371	440	1,345	900	1,597	2,340	2,602

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Belchertown Reservoir, Springfield. — *Table showing Number of Principal Organisms per Cubic Centimeter* — Continued.

	1904.								1905.						
	August 26.	August 31.	September 2.	September 12.	September 19.	September 26.	October 4.	November 9.	May 9.	May 16.	May 22.	May 31.	June 13.	June 13.	June 14.
Days after last treatment,	36	41	43	53	60	67	75	111	292	299	305	314	327	-	1
Number of samples,	4	2	4	2	2	2	2	1	1	1	1	1	2	-	2
Diatomaceæ:—														Treatment: 1 part copper sulphate to 8,000,000 parts water. Resulting concentration: 1:6,000,000.	
Asterionella,	881	1,144	1,676	644	888	1,764	1,908	249	256	736	510	1,040	770		732
Melosira,	346	32	42	8	56	152	142	12	164	328	640	1,776	812		372
Synedra,	36	40	90	200	142	300	312	31	16	84	20	32	20		12
Tabellaria,	1,277	1,324	558	1,868	1,434	2,100	1,840	498	8	8	10	56	160		160
Cyanophyceæ,	**6**	**32**	**13**	**10**	**11**	**0**	**1**	**3**	**72**	**764**	**440**	**186**	**644**		**492**
Anabæna,	0	0	0	0	0	0	0	2	72	764	440	186	644		492
Algæ:—															
Polyedrium,	208	156	374	232	136	108	75	0	0	8	0	48	32		16
Scenedesmus,	172	120	160	160	98	192	135	42	48	32	0	128	120		196
Infusoria,	**140**	**204**	**260**	**63**	**46**	**44**	**47**	**93**	**0**	**4**	**0**	**0**	**0**		**2**
Dinobryon,	95	160	202	20	6	32	25	87	0	0	0	0	0		0
Uroglena,	*	0	0	2	0	4	3	1	0	4	0	0	0		0
Total organisms,	3,694	3,903	3,561	3,863	3,082	4,959	4,667	976	582	1,994	1,655	3,452	2,663		2,090

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Belchertown Reservoir, Springfield. — Table showing Number of Principal Organisms per Cubic Centimeter — Continued.

	1905.														
	June 15.	June 16.	June 17.	June 18.	June 19.	June 20.	June 26.	June 27.	July 10.	July 11.	July 18.	July 18.	July 19.	July 21.	July 24.
Days after last treatment,	2	3	4	5	6	7	13	14	27	28	35	-	1	3	6
Number of samples,	2	2	2	2	2	5	4	1	2	1	3	-	4	4	3
Diatomaceæ:—												Treatment: 1 part copper sulphate to 8,000,000 parts water. Resulting concentration: 1:5,200,000.			
Asterionella,	422	300	200	504	404	744	701	576	196	32	13		0	0	10
Melosira,	338	130	318	1,224	2,012	1,409	904	896	1,792	2,088	553		582	678	252
Synedra,	20	26	38	24	36	24	12	16	188	96	24		10	16	3
Tabellaria,	162	184	78	192	254	189	348	280	172	128	2		0	8	1
Cyanophyceæ,	**436**	**100**	**84**	**60**	**42**	**19**	**12**	**30**	**278**	**248**	**917**		**484**	**392**	**49**
Anabæna,	436	100	84	60	42	19	12	30	278	248	904		472	384	49
Algæ:—															
Polyedrium,	46	58	70	124	250	165	110	120	92	56	37		42	14	29
Scenedesmus,	172	128	152	808	920	1,020	1,547	720	1,100	992	529		524	1,164	323
Infusoria,	**6**	**4**	**38**	**80**	**34**	**169**	**41**	**80**	**8**	**16**	**29**		**4**	**6**	**29**
Dinobryon,	6	0	12	64	20	144	6	32	0	0	0		0	0	0
Uroglena,	0	0	0	0	0	0	0	0	0	0	0		0	0	0
Total organisms,	1,678	986	1,022	3,152	4,136	4,019	3,883	2,806	4,157	3,778	2,173		1,470	1,826	755

Belchertown Reservoir, Springfield. — Table showing Number of Principal Organisms per Cubic Centimeter — Concluded.

	1905.														
	July 25.	July 28.	August 2.	August 4.	August 8.	August 22.	August 29.	September 12.	September 19.	September 26.	September 27.	October 24.	November 1.	November 7.	November 8.
Days after last treatment,	7	10	15	17	21	35	42	56	63	70	71	98	106	112	113
Number of samples,	1	4	1	2	1	1	3	1	1	1	2	1	1	1	1
Diatomaceæ:—															
Asterionella,	0	20	4	0	0	48	1	0	0	6	2	4	2	0	8
Melosira,	320	704	24	492	96	640	311	284	43	190	188	34	5	56	520
Synedra,	44	4	4	8	12	28	8	8	7	4	0	58	7	26	24
Tabellaria,	0	10	4	8	0	24	8	4	2	4	4	0	0	4	0
Cyanophyceæ,	**24**	**16**	**0**	**3**	**0**	**4**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Anabæna,	24	10	0	3	0	0	0	0	0	0	0	0	0	0	0
Algæ:—															
Polyedrium,	16	54	20	36	80	16	0	16	1	0	1	2	0	0	0
Scenedesmus,	324	2,034	184	496	492	96	160	220	20	64	40	36	4	22	56
Infusoria,	**32**	**10**	**8**	**36**	**32**	**96**	**43**	**228**	**74**	**50**	**35**	**33**	**32**	**24**	**0**
Dinobryon,	0	0	0	0	0	0	0	184	45	12	0	0	0	0	0
Uroglena,	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Total organisms,	818	3,047	342	1,345	788	1,107	675	800	166	336	301	173	55	148	898

Belchertown Reservoir.— Table showing Results of Copper Analyses.

[Unless otherwise stated, the samples examined were made up of several samples collected from different parts of the reservoir.]

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.	Mud. Quantity examined, Dry (Grams).	Mud. Parts Copper Sulphate to 100,000 Parts Dry Mud.
1904.							
July 20, . .	-	-	50	.00157	64.00	70	4.46
21, . .	Treatment: 1 part copper sulphate to 8,000,000 parts water.						
22, . .	-	1	50	.01571	6.40	80	8.83
Aug. 4, . .	Surface, .	14	50	.01021	9.80	-	-
	Bottom, .	14	50	.01099	9.10	-	-
12, . .	-	22	50	.00393	26.00	-	-
18, . .	-	28	50	.03769	2.70	25	4.71
23, . .	-	33	50	.00864	11.60	-	-
26, . .	-	36	50	.00157	64.00	50	2.36
Sept. 2, . .	-	43	50	.07852	1.30	45	10.48
12, . .	-	53	50	.00550	18.20	-	-
19, . .	-	60	50	.00314	32.00	-	-
26, . .	-	67	50	.01099	9.10	75	12.05
Oct. 4, . .	-	75	50	.00236	42.00	-	-
Nov. 9, . .	-	111	50	.00157	64.00	-	-
	Broad Brook,	111	50	.00157	64.00	-	-
1905.							
Jan. 23, . .	-	186	50	.02356	4.20	-	-
	Broad Brook,	186	50	.00157	64.00	-	-
Apr. 21, . .	-	274	50	.00157	64.00	-	-
May 22, . .	Surface, .	305	36	.00110	90.00	-	-
	Bottom, .	305	50	.00079	127.00	-	-
31, . .	-	314	50	.00079	127.00	50	7.07
June 13, . .	-	327	50	.00471	21.00	-	-
	Treatment: 1 part copper sulphate to 8,000,000 parts water.						
14, . .	Upper end, .	1	50	.01413	7.00	-	-
	Lower end, .	1	50	.01963	5.10	-	-
	Overflow, .	1	50	.01963	5.10	-	-
15, . .	Upper end, .	2	50	.01256	8.00	-	-
	Lower end, .	2	50	.00942	11.00	-	-
	Overflow, .	2	50	.01256	8.00	-	-
16, . .	Upper end, .	3	50	.00942	11.00	-	-
	Lower end, .	3	50	.01021	9.80	-	-
	Overflow, .	3	50	.01021	9.80	-	-

Belchertown Reservoir. — Table showing Results of Copper Analyses — Concluded.

[Unless otherwise stated, the samples examined were made up of several samples collected from different parts of the reservoir.]

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.	Mud. Quantity examined, Dry (Grams).	Mud. Parts Copper Sulphate to 100,000 Parts Dry Mud.
1905.							
June 20, . .	-	7	50	.00471	21.00	-	-
	Overflow, .	7	50	.00471	21.00	-	-
26, . .	-	13	50	.00314	32.00	-	-
	Inlet, . .	13	50	.00000	*	-	-
	Overflow, .	13	50	.00314	32.00	-	-
July 10, . .	-	27	50	.00157	64.00	-	-
18, . .	Treatment: 1 part copper sulphate to 8,000,000 parts water.						
19, . .	Upper end, .	1	50	.01727	5.80	-	-
	Lower end, .	1	50	.02120	4.70	-	-
21, . .	-	3	50	.00785	13.00	-	-
24, . .	-	6	50	.00314	32.00	-	-
28, . .	-	10	50	.00236	42.00	-	-
Aug. 4, . .	-	17	50	.00314	32.00	-	-
	Inlet, . .	17	50	.00236	42.00	-	-
29, . .	-	42	50	.00236	42.00	-	-
Sept. 27, . .	-	71	50	.00157	64.00	-	-

* No copper present.

Daily Rainfall in Inches at Amherst during the Period of the Experiments at Belchertown upon the Use of Copper Sulphate.

[Asterisk indicates precipitation included in that of following day.]

Day of Month.	1904.					
	July.	August.	September.	October.	November.	December.
1,	–	.01	trace	trace	–	–
2,	–	.39	.03	–	–	–
3,	–	trace	.01	–	–	–
4,	–	–	.02	–	–	trace
5,	–	–	–	trace	–	.18
6,	–	trace	–	.11	–	–
7,	–	–	–	–	–	–
8,	–	.22	trace	trace	–	.07
9,	–	–	.15	–	trace	–
10,	–	1.04	–	.05	–	–
11,	–	.21	–	.14	–	–
12,	–	–	.03	.09	–	*
13,	–	.04	trace	.13	1.10	.47
14,	–	.02	2.62	trace	–	–
15,	–	–	1.48	–	–	–
16,	–	–	–	–	–	–
17,	–	.06	–	–	–	–
18,	–	–	–	–	–	.11
19,	–	–	–	–	–	trace
20,	–	2.03	.05	trace	–	trace
21,	–	–	–	1.22	–	trace
22,	.09	.02	–	–	–	–
23,	.04	.05	–	–	–	trace
24,	.26	–	.09	–	–	–
25,	.27	–	.02	–	trace	*
26,	.01	–	.21	trace	–	.20
27,	.11	–	–	–	trace	1.11
28,	.06	–	.02	–	–	.61
29,	.17	–	.70	–	.25	trace
30,	–	–	.02	–	–	–
31,	trace	–	–	–	–	–
Totals,	1.01	4.09	5.45	1.74	1.35	2.75

Daily Rainfall in Inches at Amherst, etc. — Concluded.

[Asterisk indicates precipitation included in that of following day.]

Day of Month.	1905.										
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.
1,	–	–	–	–	trace	–	–	0.07	trace	–	–
2,	0.14	–	–	–	trace	0.04	0.03	–	0.53	–	–
3,	*	–	–	–	–	–	0.02	–	1.99	0.17	0.03
4,	0.74	–	trace	0.03	–	trace	–	–	1.98	–	0.32
5,	–	–	–	0.86	0.01	–	–	–	–	–	–
6,	*	0.68	–	0.29	0.01	0.36	–	0.18	0.22	–	0.44
7,	1.15	–	*	–	–	0.31	–	–	–	–	–
8,	trace	–	0.64	–	–	trace	trace	trace	–	–	0.04
9,	–	*	*	–	0.12	–	0.01	0.07	–	–	trace
10,	trace	0.54	0.41	trace	–	–	0.40	–	–	–	–
11,	*	–	–	0.87	–	0.01	0.02	1.34	0.22	0.20	–
12,	0.92	*	–	–	0.21	0.22	–	0.02	0.62	0.73	–
13,	–	0.48	–	–	0.03	0.32	0.03	–	–	–	trace
14,	–	–	–	0.12	0.24	–	0.26	–	–	–	–
15,	–	–	–	–	0.33	–	–	0.90	trace	–	0.03
16,	–	–	–	–	0.22	–	–	0.50	0.03	–	–
17,	trace	–	–	trace	trace	–	0.40	–	0.07	–	–
18,	–	–	–	–	0.03	trace	–	–	0.40	–	–
19,	trace	–	0.32	–	–	0.13	0.01	–	0.07	0.45	–
20,	–	trace	0.08	0.04	–	0.18	–	0.01	0.13	0.70	–
21,	*	–	0.89	0.18	–	0.78	–	–	–	–	–
22,	0.42	–	–	–	–	0.40	–	0.13	–	–	–
23,	–	–	–	–	–	0.01	0.04	–	–	–	–
24,	*	–	0.10	0.01	–	–	0.30	–	–	0.02	–
25,	0.53	–	0.88	–	–	–	–	0.89	–	–	–
26,	–	–	0.02	trace	trace	0.10	0.20	0.30	–	–	trace
27,	–	–	0.31	–	–	trace	–	0.22	–	–	–
28,	trace	–	–	–	–	–	–	–	–	trace	0.20
29,	–	–	–	0.16	0.01	–	0.39	0.10	–	–	1.00
30,	–	–	0.01	–	0.07	–	0.51	1.69	–	–	trace
31,	–	–	–	–	–	–	0.01	0.05	–	–	–
Totals,	3.90	1.70	3.66	2.56	1.28	2.86	2.63	6.47	6.26	2.27	2.06

Calculated Run-off of Belchertown Reservoir Water-shed in Million Gallons per Day, based on the Measured Run-off of an Adjoining Water-shed.

[Blank spaces indicate that no reading was taken that day.]

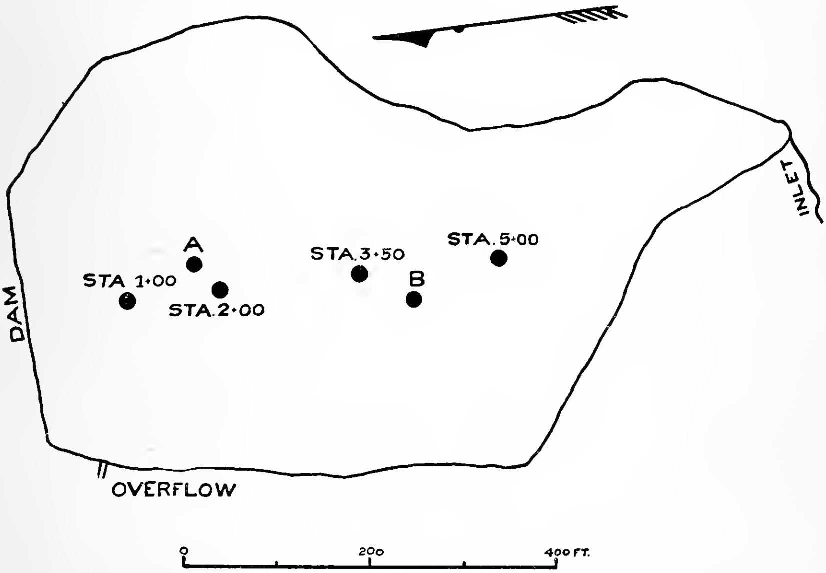
Day of Month.	1904.						1905.					
	July.	August.	September.	October.	November.	December.	May.	June.	July.	August.	September.	October.
1,	1.19	–	0.84	1.03	0.58	0.71	2.88	0.75	0.58	0.27	0.68	.31
2,	3.45	–	0.75	–	0.43	0.50	2.48	0.75	0.50	0.27	0.43	.43
3,	2.82	0.94	0.99	0.66	0.94	0.75	2.10	0.75	0.46	0.35	13.07	.39
4,	2.23	–	–	0.50	1.12	–	1.98	0.58	0.50	0.33	7.18	.46
5,	9.06	1.42	0.50	0.66	0.84	0.84	–	0.62	0.43	0.51	4.09	.39
6,	5.63	1.12	0.58	0.50	–	0.75	2.48	–	–	0.79	1.45	.37
7,	6.43	1.42	0.66	0.58	0.52	–	1.64	0.84	–	0.82	1.22	.33
8,	2.23	1.89	0.84	0.58	0.43	0.66	1.86	1.22	0.94	0.68	1.30	.22
9,	1.68	1.75	0.84	–	0.50	0.84	1.64	1.03	0.58	0.50	0.96	.31
10,	1.22	2.89	0.98	0.58	0.84	0.66	1.32	–	0.24	0.50	0.62	.31
11,	1.45	–	–	0.39	1.22	–	0.94	0.50	0.75	0.71	0.68	.30
12,	1.68	1.86	–	–	1.22	0.66	1.03	0.58	0.50	0.58	1.36	.29
13,	1.55	1.23	0.58	0.84	–	0.58	1.12	–	0.36	0.77	1.12	.19
14,	1.69	0.94	0.50	0.94	–	0.50	0.94	1.12	0.50	0.68	0.86	.46
15,	1.22	0.84	17.98	1.32	–	0.50	1.12	0.84	0.50	0.77	0.77	.27
16,	1.22	0.50	7.25	0.84	–	–	3.87	0.66	0.36	1.03	0.68	.35
17,	0.98	0.58	1.86	–	–	–	4.07	0.58	0.29	0.92	0.65	.39
18,	0.98	1.03	1.22	–	–	–	3.29	0.43	0.36	0.43	0.91	.22
19,	0.98	0.71	1.22	0.62	0.58	0.43	2.88	0.75	0.39	0.43	1.00	.24
20,	0.98	3.29	1.12	–	0.58	0.36	2.35	0.66	0.66	0.27	0.91	.55
21,	1.22	2.35	–	–	–	0.43	1.64	0.66	0.39	0.35	0.91	.87
22,	1.22	1.64	–	0.66	–	–	1.75	1.22	0.36	0.24	0.65	.66
23,	0.77	2.07	0.84	–	0.94	0.43	1.03	0.50	0.24	0.24	0.54	.43
24,	1.69	1.42	0.75	0.75	1.03	0.66	1.12	3.29	0.29	0.22	0.43	.39
25,	0.77	1.22	0.94	–	0.94	–	1.03	2.11	0.36	0.24	0.54	.39
26,	–	0.84	0.84	–	0.75	–	1.22	1.64	0.33	0.31	0.40	.33
27,	–	1.03	0.84	0.58	–	1.03	1.42	1.22	0.29	0.29	0.29	.40
28,	0.66	0.94	–	0.66	1.12	3.72	–	0.84	0.24	0.31	0.43	.33
29,	0.93	1.03	0.58	0.75	0.75	4.07	1.22	0.84	0.50	0.25	0.41	.27
30,	0.93	0.94	0.84	–	0.80	2.64	1.12	1.03	0.36	0.33	0.35	.33
31,	0.84	0.66	–	0.50	–	1.98	0.84	–	0.50	0.97	–	.27

NOTE. — The reservoir, at the time of the beginning of the experiments, had a water-shed of 2.9 square miles; but since July, 1905, the flow from a portion of the water-shed of Broad Brook has been diverted into the Jabish Brook canal, leaving a water-shed of 1.2 square miles tributary to the reservoir.

Lexington Reservoir.

Lexington Reservoir was built upon Vine Brook by the Lexington Water Company in the year 1893, but its use as a source of water supply was discontinued when water was introduced from the Metropolitan Water District in 1903. It was designed to have a capacity of a little over 14,000,000 gallons, but owing to leakage the amount usually in store is considerably less than the full capacity of the reservoir.

At the time the experiments were made the area of the reservoir was about 6.2 acres and the quantity of water stored about 8,000,000 gallons. Its maximum depth was 6½ feet and its general depth about 4½ feet.



Lexington Reservoir.

The soundings indicated that the bottom was covered with soft material overgrown with a small organism, but there are no large aquatic plants growing in the reservoir. The water-shed is very limited, amounting to about .3 of a square mile.

Soon after its construction the water of this reservoir was affected by the presence of organisms. The Infusoria, *Uroglena* and *Synura,* have been present frequently, and at times small numbers of *Anabæna.*

The quantity of organic matter ordinarily present in the water is much less than is found in that of the Arlington or Belchertown reservoirs, and the color is low.

This reservoir was first treated with copper sulphate in March, 1905, for the purpose of determining the diffusion of copper under ice. On March 1, 1905, 63 pounds of copper sulphate, equivalent to 1 part of copper sulphate to 1,000,000 parts of water, were applied to this reservoir in four burlap sacks suspended in the water near the surface through a hole in the ice. The sacks were agitated from time to time, to hasten the solution of the copper sulphate, which required about five hours. The point at which the copper sulphate was applied to the reservoir was 200 feet from the dam. After the chemical had been applied holes were cut in the ice in a line running from the dam to the upper end of the reservoir, the first one 100 feet from the dam and half-way between the dam and the point at which the copper sulphate was applied; the next, 350 feet from the dam and 150 feet from the point of treatment; while the last one was cut near the upper end of the reservoir, 500 feet from the dam and 300 feet from the point at which the copper sulphate was applied.

The number of organisms present in the water at the time the copper sulphate was applied was insignificant. A sample of water collected in July, 1904, was found to be free from copper, but copper was found in the mud in a quantity equivalent to 3.53 parts of copper sulphate in 100,000 parts of dry mud. Samples of water collected just before applying the copper sulphate showed the presence of 1 part of copper sulphate to 32,000,000 parts of water at the surface at one point and none at another point, and 1 part in 64,000,000 parts of water at the bottom.

After the copper sulphate had been applied samples were collected at Station 1, 100 feet from the dam, at Station 2, 200 feet from the dam, — the point at which copper sulphate was applied, — at Station 3+50, 350 feet from the dam, and at Station 5, 500 feet from the dam, at frequent intervals, to determine how long it would take the copper sulphate to diffuse in the water so as to affect the water at the various stations.

As already stated, the copper sulphate was applied on March 1, and samples were collected on March 1, 2, 6, 9 and 16. After the latter date the ice became unsafe, and disappeared from the reservoir by the first of April. Samples were then taken on April 4 and 26, May 25 and June 23 and 30. The results of these examinations are given in a table appended hereto.

On the day after the application of the copper sulphate at Station 2 copper was found only in the water beneath the point at which it had been applied, being concentrated in greater quantity at the surface of the water than near the bottom. On March 2 the quantity had diminished at this point, but had not spread out to either of the other points of observation. On March 6 it had spread along the bottom

of the reservoir, so that its presence was noted at Station 1, 100 feet nearer the dam. On March 9 the quantity present at the bottom of Station 1 was quite marked, but there was no evidence that it had affected the surface water there or spread to the other stations. On March 16 the effect had become still more notable in the bottom water at Station 1, but the surface water was still unaffected. The copper sulphate had also spread along the bottom of the reservoir in the opposite direction so as to affect the bottom water at Station 3+50, 150 feet from the point of application.

After the disappearance of the ice from the reservoir the copper was found on April 4 to be quite evenly distributed, except that it was more concentrated along the bottom, especially at Station 1. On April 26 the analyses showed an even distribution of the copper in all parts of the reservoir, and from this time the quantity diminished quite rapidly, but the quantity found in different samples varied greatly.

As already stated, the water of the reservoir was practically free from organisms when the copper sulphate was applied, on March 1. *Synedra* and *Dinobryon* appeared in considerable numbers on April 26, when the copper sulphate had diffused throughout the reservoir in a quantity equivalent to 1 part in 21,000,000 parts of water, showing that this quantity of copper sulphate did not prevent the development of these organisms. *Uroglena* appeared on June 23 and increased until June 29, when large numbers were present in the water of the reservoir.

Copper sulphate was applied again on June 30, in a quantity equivalent to 1 part of copper sulphate to 20,000,000 parts of water. The reservoir water contained already at this time 1 part of copper sulphate in 25,000,000 parts of water, and on July 1 the quantity of copper sulphate present in the water was found to be 1 part in 12,000,000 parts of water. The *Uroglena* gradually disappeared and none was found after July 7. *Synedra* grew in considerable numbers during July, but the number of organisms during the remainder of the year up to October was insignificant. The quantity of copper present in the water subsequently varied greatly, but gradually diminished from the time the last application was made, on June 30, though a sample collected on October 12 showed that the water at that time still contained about half as much copper as was present in the water after the copper sulphate was applied on June 30.

Chemical Examinations of Water from Lexington Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1905.																
53138	Feb. 28	V. slight.	Slight.	.17	Faintly vegetable.	Faintly vegetable.	4.50	1.35	.0166	.0186	.0130	.0056	.45	.0130	.0001	.27	1.8
53139	Mar. 1	V. slight.	Slight.	.19	Faintly vegetable.	Faintly vegetable.	5.35	1.60	.0126	.0198	.0148	.0050	.47	.0130	.0001	.31	1.7
53140	Mar. 2	V. slight.	Slight.	.17	Faintly vegetable.	Faintly vegetable.	4.90	1.60	.0204	.0194	.0164	.0030	.48	.0130	.0001	.31	1.8
53141	Mar. 6	V. slight.	Slight.	.17	Faintly vegetable.	Faintly vegetable.	4.95	1.65	.0102	.0196	.0162	.0034	.48	.0130	.0001	.31	1.8
-	Mar. 9	-	-	.12	- -	- -	4.02	1.27	.0383	.0217	.0163	.0054	.43	.0155	.0002	.30	1.3
-	Mar. 16	-	-	.23	- -	- -	4.57	1.45	.0081	.0201	.0147	.0054	.42	.0230	.0002	.43	1.3
53878	Apr. 26	V. slight.	Slight.	.21	Faintly vegetable and sweetish.	Distinctly vegetable and sweetish.	3.90	1.35	.0016	.0276	.0172	.0104	.33	.0020	.0001	.33	1.3
54911	June 3	V. slight.	Slight.	.21	Faintly unpleasant.	Distinctly oily.[1]	3.70	1.35	.0012	.0260	.0238	.0022	.33	.0010	.0001	.47	1.1
-	July 3	-	-	.18	- -	- -	4.15	1.77	.0028	.0291	.0251	.0040	.36	.0017	.0001	.45	1.3
-	July 7	-	-	.22	- -	- -	3.92	1.55	.0042	.0262	.0208	.0054	.35	.0010	.0000	.43	1.3
55465	July 24	V. slight.	Slight.	.18	V. faintly vegetable.	Faintly vegetable.	3.60	1.50	.0024	.0272	.0222	.0050	.38	.0040	.0002	.42	1.3
-	July 25	-	-	.13	- -	- -	4.25	1.65	.0024	.0370	.0280	.0090	.38	.0020	.0001	.41	1.3
55806	Aug. 6	Slight.	V. slight.	.14	V. faintly vegetable.	Distinctly vegetable.	3.80	1.60	.0020	.0274	.0192	.0082	.43	.0020	.0001	.32	1.0
-	Aug. 31	-	-	.14	- -	- -	4.27	1.77	.0024	.0246	.0212	.0034	.42	.0010	.0000	.32	2.2
-	Oct. 12	-	-	.15	- -	- -	4.77	1.72	.0021	.0285	.0234	.0051	.38	.0020	.0000	.40	1.4

[1] *Uroglena.*

Lexington Reservoir. — Table showing Number of Principal Organisms per Cubic Centimeter.

	1905.										
	February 28.	March 1.	March 1.	March 2.	March 6.	March 9 (Surface).	March 9 (Bottom).	March 16 (Surface).	March 16 (Bottom).	April 17.	April 26.
Days after last treatment,	–	–	–	1	5	8	8	15	15	47	56
Number of samples, . .	1	–	1	1	1	1	1	1	1	2	1
Diatomaceæ:—											
Synedra, . . .	0	Treatment: 1 part copper sulphate to 1,000,000 parts water.	0	0	0	0	0	1	0	30	390
Algæ:—											
Raphidium, . . .	0		0	0	0	0	0	0	0	4	0
Infusoria:—											
Chlamydomonas, .	0		0	0	0	0	0	0	0	112	0
Dinobryon, . . .	0		0	0	0	0	0	0	0	51	882
Peridinium, . . .	15		7	2	1	14	22	0	4	*	20
Uroglena, . . .	0		0	0	0	0	0	0	0	0	0
Total organisms, .	19		15	5	5	19	32	37	9	229	1,346

	1905.													
	June 23.	June 29.	June 30.	June 30.	July 1.	July 3.	July 5.	July 7.	July 17.	July 24.	July 25.	August 6.	August 31.	October 12.
Days after last treatment,	114	120	121	–	1	3	5	7	17	24	25	37	62	104
Number of samples, . .	1	2	5	–	5	7	4	7	2	1	2	1	2	2
Diatomaceæ:—														
Synedra, . . .	3	4	*	Additional treatment: 1 part copper sulphate to 20,000,000 parts water. Resulting concentration: 1 : 12,000,000.	*	7	17	56	470	360	84	6	2	0
Algæ:—														
Raphidium, . . .	0	64	180		54	131	449	210	86	2	0	7	30	7
Infusoria:—														
Chlamydomonas, .	0	0	0		0	0	0	0	0	0	0	0	0	0
Dinobryon, . . .	0	0	0		0	0	0	0	0	0	0	0	0	0
Peridinium, . . .	2	1	0		*	*	1	3	3	2	3	9	5	*
Uroglena, . . .	16	26	†		6	2	1	†	0	0	0	0	5	0
Total organisms, .	32	105	192		65	150	472	281	572	371	101	29	88	22

* The organism was present in some samples but not in others, the average number of organisms being less than 1. † Broken up.

Lexington Reservoir.— Table Showing Results of Copper Analyses.

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.	Mud. Quantity examined, Dry (Grams).	Mud. Parts Copper Sulphate to 100,000 Parts Dry Mud.
1904. July 12,	-	-	15	0.00000	*	100	3.53
1905. Feb. 28,	A — Surface, .	-	50	0.00314	32.00	-	-
	Bottom, .	-	50	0.00157	64.00	-	-
	B — Surface, .	-	50	0.00000	*	-	-
Mar. 1,	Treatment: at Station 2 with 63 pounds of copper sulphate, equivalent to 1 part copper sulphate to 1,000,000 parts water. The copper sulphate was dissolved through a hole in the ice which covered the reservoir at this time.						
1,	1 — Surface, .	-	45	0.00173	59.00	-	-
	Bottom, .	-	45	0.00173	59.00	-	-
	2 — Surface, .	-	12	1.44610	0.07	-	-
	Bottom, .	-	30	0.41616	0.24	-	-
	3 + 50 — Surface,	-	36	0.00220	45.00	-	-
	Bottom,	-	36	0.00000	*	-	-
2,	1 — Surface, .	1	36	0.00326	31.00	-	-
	Bottom, .	1	36	0.00110	90.00	-	-
	2 — Surface, .	1	50	0.03455	2.90	-	-
	Bottom, .	1	45	0.04099	2.40	-	-
	3 + 50 — Surface,	1	36	0.00326	31.00	-	-
	Bottom,	1	36	0.00000	*	-	-
6,	1 — Surface, .	5	36	0.00000	*	-	-
	Bottom, .	5	36	0.00872	11.50	-	-
	2 — Surface, .	5	45	0.05932	1.70	-	-
	Bottom, .	5	45	0.02006	5.00	-	-
	3 + 50 — Surface,	5	36	0.00220	45.00	-	-
	Bottom,	5	36	0.00220	45.00	-	-
9,	1 — Surface, .	8	36	0.00220	45.00	-	-
	Bottom, .	8	36	0.01417	7.00	-	-
	2 — Surface, .	8	36	0.23556	0.42	-	-
	Bottom, .	8	36	0.05457	1.80	-	-
	3 + 50 — Surface,	8	36	0.00000	*	-	-
	Bottom,	8	36	0.00220	45.00	-	-
16,	1 — Surface, .	15	36	0.00220	45.00	-	-
	Bottom, .	15	36	0.02073	4.80	-	-
	2 — Surface, .	15	36	0.00872	11.50	-	-
	Bottom, .	15	36	0.02725	3.70	-	-
	3 + 50 — Surface,	15	36	0.00220	45.00	-	-
	Bottom,	15	36	0.00762	13.00	-	-
	5 — Surface, .	15	36	0.00000	*	-	-
	Bottom, .	15	36	0.00220	45.00	-	-
Apr. 1,			Ice gone from reservoir.				
4,	1 — Surface, .	34	36	0.00656	15.00	-	-
	Bottom, .	34	36	0.01307	7.70	-	-
	2 — Surface, .	34	36	0.00656	15.00	-	-
	Bottom, .	34	36	0.00762	13.00	-	-

* No copper present.

Lexington Reservoir, etc. — Concluded.

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.	Mud. Quantity examined, Dry (Grams).	Mud. Parts Copper Sulphate to 100,000 Parts Dry Mud.
1905.							
Apr. 4,	3 + 50 — Surface,	34	36	0.00656	15.00	-	-
	Bottom,	34	36	0.00762	13.00	-	-
	5 — Surface, .	34	36	0.00546	18.00	-	-
	Bottom, .	34	36	0.00656	15.00	-	-
	2 - .	34	-	-	-	10	687.05
26,	1 — Surface, .	56	50	0.00471	21.00	-	-
	Bottom, .	56	50	0.00471	21.00	-	-
	2 — Surface, .	56	50	0.00471	21.00	-	-
	Bottom, .	56	36	0.00436	23.00	-	-
	3 + 50 — Surface,	56	50	0.00471	21.00	-	-
	Bottom,	56	50	0.00471	21.00	-	-
	5 — Surface, .	56	50	0.00471	21.00	-	-
	Bottom, .	56	50	0.00471	21.00	-	-
May 25,	1 — Surface, .	85	36	0.00326	31.00	-	-
	Bottom, .	85	50	0.00550	18.00	-	-
	5 — Surface, .	85	50	0.00393	25.00	-	-
	Bottom, .	85	50	0.00393	25.00	-	-
	2 -	85	-	-	-	A sample of mud mixed with the bottom water was collected; the mud was filtered out and the water and mud were then analyzed separately. The water contained copper sulphate in the ratio of 1 part copper sulphate to 36,000,000 parts water; the mud contained 27.9 parts copper sulphate to 100,000 parts water.	
June 23,	1 — Surface, .	114	50	0.00000	*	-	-
	Bottom, .	114	36	0.00110	90.00	-	-
	5 — Surface, .	114	50	0.00000	*	-	-
	Bottom, .	114	50	0.00157	64.00	-	-
30,	-	121	50	0.00393	25.00	-	-
	Additional treatment: 1 part copper sulphate to 20,000,000 parts water.						
July 1,	-	1	50	0.00864	12.00	-	-
3,	-	3	50	0.00550	18.00	-	-
7,	1 — Surface, .	7	50	0.00471	21.00	-	-
	Bottom, .	7	50	0.00628	16.00	-	-
	5 — Surface, .	7	50	0.00628	16.00	-	-
	Bottom, .	7	50	0.00471	21.00	-	-
25,	-	25	50	0.00314	32.00	-	-
Aug. 31,	-	62	50	0.00236	42.00	-	-
Oct. 12,	-	104	50	0.00393	25.00	-	-

* No copper present.

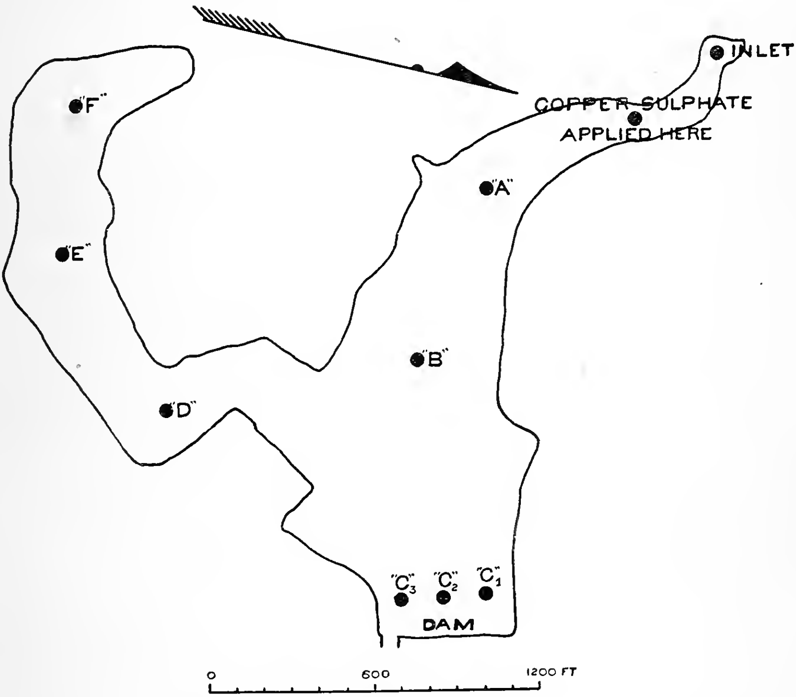
Lexington Reservoir.— Table showing Amount of Copper Sulphate in the Reservoir at Various Times during the Year 1905, expressed in Million Parts of Water to One Part of Copper Sulphate.

	February 28.	March 1.	March 1.	March 2.	March 6.	March 9.	March 16.		April 4.	April 26.	May 25.	June 23.	June 30.		July 1.	July 3.	July 7.	July 25.	August 31.	October 12.
Days after last treatment, . .	-	-	-	1	5	8	15	-	34	56	85	114	121	-	1	3	7	25	62	104
Station.																				
A — Surface, ...	32.0	Treatment: 1 part copper sulphate to 1,000,000 parts water.	-	-	-	-	-	Ice left reservoir.	-	-	-	-	-	Treatment: 1 part copper sulphate to 20,-000,000 parts water.	-	-	-	-	-	-
Bottom, ...	64.0		-	-	-	-	-		-	-	-	-	-		-	-	-	-	-	-
B — Surface, ...	*		-	-	-	-	-		-	-	-	-	-		-	-	-	-	-	-
1 — Surface, ...	-		59.000	31.0	*	45.00	45.0		15.0	21.0	31.0	*	-		-	-	21.0	-	-	-
Bottom, ...	-		59.000	90.0	11.5	7.00	4.8		7.7	21.0	18.0	90.0	-		-	-	16.0	-	-	-
2 — Surface, ...	-		.069	2.9	1.7	.42	11.5		15.0	21.0	-	-	-		-	-	-	-	-	-
Bottom, ...	-		.240	2.4	5.0	1.80	3.7		13.0	23.0	-	-	-		-	-	-	-	-	-
3 + 50 — Surface, . . .	-		45.000	31.0	45.0	*	45.0		15.0	21.0	-	-	-		-	-	-	-	-	-
Bottom, ...	-		*	*	45.0	45.00	13.0		13.0	21.0	-	-	-		-	-	-	-	-	-
5 — Surface, ...	-		-	-	-	-	*		18.0	21.0	25.0	*	-		-	-	16.0	-	-	-
Bottom, ...	-		-	-	-	-	45.0		15.0	21.0	25.0	64.0	-		-	-	21.0	-	-	-
Composite sample, . . .	-		-	-	-	-	-		-	-	-	-	25.0		12.0	18.0	-	32.0	42.0	25.0

* No copper present.

QUINCY RESERVOIR.

Quincy Reservoir was built in 1887 for use as a source of water supply for the city of Quincy, but its use was discontinued when the Metropolitan water supply was introduced in 1898. The reservoir has an area of about 47 acres, and holds, when full, about 180,000,000 gallons. Its maximum depth is 28 feet and its average depth about 12 feet. The bottom is covered in most places with mud, and contains a considerable number of stumps. The water-shed, which has an area of 1.5 square



QUINCY RESERVOIR.

miles, contains a considerable area of swamp land; and the water of the reservoir is highly colored and contains a large quantity of organic matter, though its quality is naturally less objectionable than that of the Belchertown or Arlington reservoirs.

The reservoir is of peculiar shape, consisting of two widely separated arms which join at the dam. The main feeder of the reservoir flows into the upper end of one of the arms, while the other arm occupies a narrow and crooked valley with a very small water-shed, so that it receives no considerable amount of water.

The water of the reservoir has contained organic growths of various kinds, and frequently large numbers of organisms; but this source has not been characterized by any special growth, as is the case with several of the reservoirs treated.

On account of the irregular shape of the reservoir the diffusion of copper sulphate could here be tested under unfavorable conditions, and a test was made for this purpose at about the same time that a similar test was being made in the Lexington reservoir, where the conditions for the diffusion of the copper were deemed more favorable. In making this test it was decided to apply the copper sulphate at the upper end of the northerly arm, into which the principal stream feeding the reservoir discharges, and to locate stations down the length of this arm and up to the upper end of the southerly arm, and test frequently the quantity of copper at these stations at various depths. Accordingly, sampling stations were selected at three points down the northerly arm of the reservoir, at three points across the reservoir a short distance above and parallel with the dam, and at three points running up the south arm. On March 7, samples were taken at several of these stations before copper sulphate was applied, and copper was found to be present in a very small quantity in the bottom at one of the stations in the easterly arm. It should be noted here that copper had been found in the previous year in the stream entering the reservoir, and also a very small quantity in the water of the reservoir itself.

On March 7, 1,500 pounds of copper sulphate, equivalent to 1 part of copper sulphate in 1,000,000 parts of water, were applied to the northerly arm of the reservoir at a point about 300 feet from the inlet. The copper sulphate was dissolved in 45 burlap sacks suspended in the water through holes in the ice. The sacks were agitated from time to time, and the whole of the copper sulphate was dissolved in about three hours.

Immediately after the copper sulphate had been applied, samples were taken at the various observation stations, and the quantity of copper determined. Another series of samples was collected on the next day, March 8, and others on March 10, 14 and 22. Soon after the last date the ice left the reservoir, and samples were then collected at intervals up to October 18.

The results of the test were similar to those obtained in the test at Lexington. The copper sulphate sank to the bottom of the reservoir at the point at which it was applied, and moved slowly along the bottom toward the dam, while the ice remained upon the reservoir. As soon as the ice disappeared the copper sulphate became diffused throughout all parts of the reservoir, even to the extreme upper end of the southerly arm, though the quantity present there was less than in other parts of

the reservoir. The quantity of copper present in the water gradually diminished, though the quantity was still large in some of the samples up to the close of the experiment, on October 18.

As has already been stated, the reservoir is not affected by any specific organism. A number of organisms grew in the reservoir during the season, but at no time were the numbers as great as in the other reservoirs in which experiments were made.

The quantity of copper in the water at different times, the general character of the organic growths and the chemical condition of the water, are shown in tables appended hereto. An approximate estimate of the quantity of water flowing through the reservoir during the experiments can be obtained from the records of flow from the Sudbury River water-shed, given on page 230. The rainfall at Chestnut Hill, about 10 miles from the reservoir, is given on page 231.

Chemical Examinations of Water from Quincy Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1905.																
52987	Feb. 20	Slight.	V. slight.	.55	Faintly vegetable.	Distinctly vegetable.	5.25	2.00	.0088	.0302	.0282	.0020	.81	.0140	.0002	.54	1.1
–	Mar. 7	–	–	.42	– –	– –	4.14	1.52	.0112	.0147	.0125	.0022	.72	.0112	.0001	.37	0.9
–	Mar. 14	–	–	.28	– –	– –	3.12	1.20	.0113	.0156	.0113	.0043	.49	.0130	.0002	.38	0.5
53339	Mar. 20	V. slight.	V. slight.	.33	Faintly vegetable.	Distinctly vegetable.	3.30	1.20	.0038	.0136	.0116	.0020	.51	.0110	.0001	.39	0.6
53773	Apr. 17	Slight.	Cons.	.42	Faintly vegetable.	Faintly vegetable.	3.50	1.45	.0072	.0204	.0120	.0084	.61	.0150	.0001	.42	0.8
53927	May 1	Slight.	Slight.	.43	Faintly vegetable.	Distinctly vegetable.	3.35	1.15	.0020	.0160	.0136	.0024	.62	.0100	.0001	.42	0.8
53955	May 2	Slight.	Slight.	.39	Distinctly vegetable.	Distinctly vegetable.	3.70	1.50	.0014	.0160	.0138	.0022	.61	.0100	.0002	.46	0.6
54195	May 15	V. slight.	Slight.	.38	V. faintly vegetable.	Faintly vegetable.	3.60	1.45	.0028	.0360	.0268	.0092	.62	.0080	.0001	.45	0.8
–	May 29	–	–	.33	– –	– –	3.52	1.27	.0021	.0189	.0158	.0031	.65	.0070	.0001	.42	0.6
54667	June 12	Slight.	Slight.	.37 [1]	Faintly vegetable.	Distinctly vegetable.	3.30	1.50	.0040	.0208	.0168	.0040	.66	.0040	.0001	.43	0.5
54938	June 26	Slight.	Slight.	.37	Faintly unpleasant.	Faintly unpleasant.	3.65	1.85	.0026	.0204	.0178	.0026	.65	.0020	.0001	.48	0.8
–	July 7	–	–	.41	– –	– –	3.50	1.60	.0032	.0215	.0180	.0035	.65	.0025	.0001	.45	0.7
55205	July 10	Slight.	Slight.	.40	Faintly unpleasant.	Faintly unpleasant.	3.70	1.60	.0022	.0238	.0198	.0040	.64	.0040	.0002	.45	0.6
55515	July 24	Decided.	Cons.	.47	V. faintly vegetable.	Faintly vegetable.	3.80	1.65	.0020	.0236	.0166	.0070	.67	.0010	.0001	.43	0.8
–	Aug. 3	–	–	.44	– –	– –	3.50	1.40	.0032	.0204	.0154	.0050	.68	.0005	.0000	.46	0.7
55814	Aug. 7	Slight.	Slight.	.40	Faintly vegetable.	Distinctly vegetable.	3.90	1.85	.0020	.0220	.0178	.0042	.74	.0010	.0000	.43	0.8
56202	Aug. 21	V. slight.	Slight.	.35	V. faintly vegetable.	Faintly vegetable.	4.10	1.55	.0048	.0216	.0188	.0028	.74	.0030	.0001	.46	0.8

–	Aug. 30	–	–	.34	– –	– –	3.77	1.82	.0020	.0208	.0168	.0040	.69	.0015	.0000	.45	0.6
56519	Sept. 5	V. slight.	Cons.	.32	Faintly vegetable.	Distinctly vegetable.	3.75	1.40	.0036	.0200	.0178	.0022	.70	.0010	.0001	.48	0.8
56842	Sept. 19	V. slight.	Cons.	.37	Faintly vegetable.	Distinctly vegetable.	3.75	0.80	.0052	.0198	.0178	.0020	.70	.0040	.0001	.52	1.3
57209	Oct. 2	V. slight.	Slight.	.42	Faintly vegetable.	Distinctly vegetable.	4.20	1.60	.0036	.0224	.0192	.0032	.74	.0010	.0000	.43	0.6
57513	Oct. 16	V. slight.	Slight.	.52	Faintly vegetable.	Distinctly vegetable.	3.95	1.70	.0066	.0240	.0186	.0054	.75	.0020	.0000	.32	0.8
–	Oct. 18	–	–	.61	– –	– –	4.50	1.82	.0072	.0220	.0184	.0036	.72	.0065	.0002	.36	0.8
57745	Oct. 30	Slight.	Slight.	.49	Faintly vegetable.	Faintly vegetable.	3.95	1.50	.0082	.0204	.0188	.0016	.71	.0030	.0001	.37	0.8
58086	Nov. 13	V. slight.	Slight.	.48	Faintly vegetable.	Faintly vegetable.	3.90	1.50	.0056	.0184	.0162	.0022	.69	.0030	.0001	.38	0.8

[1] Filtered.

Quincy Reservoir. — *Table showing Number of Principal Organisms per Cubic Centimeter.*

	1905.																										
	February 20.	March 7.	March 7.	March 14.	March 20.	April 17.	May 1.	May 2.	May 12.	May 15.	May 29.	June 12.	June 26.	July 7.	July 10.	July 24.	July 26.	August 3.	August 7.	August 21.	August 30.	September 5.	September 19.	October 3.	October 16.	October 18.	October 30.
Days after last treatment,	–	–	–	7	13	41	55	56	66	69	83	97	111	122	125	139	141	149	153	167	176	182	196	210	223	225	237
Number of samples,	1	6	–	5	1	3	1	1	2	1	3	1	1	2	1	1	2	2	1	1	2	1	1	1	1	2	1
Diatomaceæ:—			Treatment at point between inlet and A with 1,500 pounds copper sulphate, equivalent to 1 part copper sulphate to 1,000,000 parts water. The copper sulphate was dissolved through a hole in the ice which covered the reservoir at this time.																								
Synedra,	0	*		*	0	9	5	30	15	8	181	2,256	12	25	36	44	46	15	12	1	6	0	0	0	0	0	0
Cyanophyceæ,	1	*		0	0	0	0	0	1	0	*	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0
Algæ:—																											
Protococcus,	0	0		0	0	0	0	0	0	0	0	68	0	0	0	788	884	748	632	4	3	0	0	0	0	0	0
Raphidium,	0	0		0	0	*	132	106	81	4	16	16	102	2	5	0	20	23	0	0	23	55	18	12	0	4	0
Infusoria,	0	13		9	1	1	1	12	18	3	0	1	2	1	0	26	3	6	4	6	95	237	17	14	14	13	11
Dinobryon,	0	6		5	0	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	84	234	5	0	0	0	0
Mallomonas,	0	6		2	1	0	0	0	0	0	0	0	0	0	0	2	0	4	4	1	2	0	1	3	0	0	1
Monas,	0	0		0	0	1	0	0	5	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	*	0
Peridinium,	0	0		0	0	0	0	0	0	0	0	1	0	0	0	24	2	0	0	0	0	0	0	1	0	0	0
Total organisms,	4	19		13	3	27	149	177	141	31	308	2,432	125	40	50	888	980	805	686	46	165	298	46	29	38	43	20

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Quincy Reservoir.— Table showing Results of Copper Analyses.

DATE.	Location.	Days after Last Treatment.	WATER. Quantity examined (Litres).	Parts Copper Sulphate to 100,000 Parts Water.	Million Parts Water to 1 Part Copper Sulphate.
1904.					
Nov. 11, . .	Reservoir, ...	–	50	0.00236	42.00
	Inlet, ...	–	50	0.01335	7.50
1905.					
Mar. 7, . . (A.M.)	A — Surface, . . .	–	50	0.00000	*
	Bottom, . . .	–	35	0.00000	*
	C_2 — Surface, . . .	–	50	0.00000	*
	Bottom, . . .	–	50	0.00000	*
	E — Surface, . . .	–	50	0.00000	*
	Bottom, . . .	–	50	0.00314	32.00
	Treatment at point between inlet and A with 1,500 pounds of copper sulphate, equivalent to 1 part copper sulphate to 1,000,000 parts water. The copper sulphate was dissolved through a hole in the ice which covered the reservoir at this time.				
(P.M.)	Inlet, surface, . . .	–	45	0.00263	38.00
	A — Surface, . . .	–	45	0.00263	38.00
	Bottom, . . .	–	1.5	4.03080	0.03
	B — Surface, . . .	–	45	0.00785	13.00
	Mid-depth, . .	–	45	0.00086	116.00
	Bottom, . . .	–	45	0.00173	59.00
	C_1 — Surface, . . .	–	45	0.00263	38.00
	Mid-depth, . .	–	45	0.00173	59.00
	Bottom, . . .	–	45	0.00086	116.00
	C_2 — Surface, . . .	–	45	0.00086	116.00
	Mid-depth, . .	–	45	0.00173	59.00
	Bottom, . . .	–	36	0.00110	90.00
	C_3 — Surface, . . .	–	45	0.00263	38.00
	Bottom, . . .	–	36	0.01307	7.70
	D — Surface, . . .	–	45	0.00086	116.00
	Bottom, . . .	–	45	0.00173	59.00
8, . .	Inlet, surface, . . .	1	45	0.00173	59.00
	A — Surface, . . .	1	45	0.00522	19.00
	Bottom, . . .	1	30	0.01570	6.40
	B — Surface, . . .	1	45	0.00263	38.00
	Mid-depth, . .	1	45	0.00086	116.00
	Bottom, . . .	1	45	0.00173	59.00
	C_1 — Surface, . . .	1	36	0.00220	45.00
	Bottom, . . .	1	45	0.00086	116.00
	C_2 — Surface, . . .	1	45	0.00263	38.00
	Mid-depth, . .	1	45	0.00086	116.00
	Bottom, . . .	1	45	0.00000	*
	C_3 — Surface, . . .	1	45	0.00173	59.00
	Bottom, . . .	1	45	0.00000	*
	D — Surface, . . .	1	45	0.00173	59.00
	Bottom, . . .	1	45	0.00000	*
10, . .	Inlet, surface, . . .	3	45	0.00263	38.00
	A — Surface, . . .	3	45	0.00173	59.00
	Bottom, . . .	3	45	0.00349	29.00

* No copper present.

Quincy Reservoir.— Table showing Results of Copper Analyses— Continued.

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.
1905. Mar. 10,	B — Surface,	3	45	0.00086	116.00
	Mid-depth,	3	45	0.00000	*
	Bottom,	3	45	0.00086	116.00
	C_1 — Surface,	3	45	0.00086	116.00
	Mid-depth,	3	45	0.00000	*
	Bottom,	3	45	0.00699	14.00
	C_2 — Surface,	3	45	0.00086	116.00
	Mid-depth,	3	45	0.00173	59.00
	Bottom,	3	45	0.00086	116.00
	C_3 — Surface,	3	36	0.00110	90.00
	Bottom,	3	45	0.00086	116.00
	D — Surface,	3	45	0.00086	116.00
	Bottom,	3	45	0.00086	116.00
14,	Inlet, surface,	7	45	0.00173	59.00
	A — Surface,	7	30	0.00130	77.00
	Bottom,	7	45	0.01743	5.70
	B — Surface,	7	36	0.00110	90.00
	Mid-depth,	7	36	0.00110	90.00
	Bottom,	7	36	0.06545	1.50
	C_1 — Surface,	7	20	0.00000	*
	C_2 — Surface,	7	36	0.00220	45.00
	Mid-depth,	7	36	0.00220	45.00
	Bottom,	7	18	0.00220	45.00
	C_3 — Surface,	7	18	0.00220	45.00
	D — Surface,	7	36	0.00220	45.00
	Bottom,	7	36	0.00220	45.00
22,	A — Surface,	15	45	0.00086	116.00
	Bottom,	15	45	0.00522	19.00
	B — Surface,	15	45	0.00086	116.00
	Bottom,	15	45	0.01743	5.70
	C_1 — Surface,	15	45	0.00086	116.00
	C_2 — Surface,	15	45	0.00173	59.00
	C_3 — Surface,	15	45	0.00000	*
	D — Surface,	15	45	0.00086	116.00
	Bottom,	15	45	0.00173	59.00
		Ice left reservoir.			
Apr. 10,	Inlet, surface,	34	-	0.00349	29.00
	A — Surface,	34	-	0.03314	3.00
	Bottom,	34	-	0.02968	3.40
	B — Surface,	34	-	0.03314	3.00
	Mid-depth,	34	45	0.03926	2.60
	Bottom,	34	45	0.03577	2.80
	C_1 — Surface,	34	45	0.03314	3.00
	Mid-depth,	34	45	0.03314	3.00
	Bottom,	34	45	0.03753	2.70

* No copper present.

Quincy Reservoir.— Table showing Results of Copper Analyses— Continued.

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.
1905.					
Apr. 10,	C_2 — Surface,	34	45	0.03753	2.70
	Mid-depth,	34	45	0.03490	2.90
	Bottom,	34	45	0.03577	2.80
	C_3 — Surface,	34	45	0.03753	2.70
	Bottom,	34	45	0.03753	2.70
	D — Surface,	34	45	0.03404	2.90
	Bottom,	34	45	0.03926	2.60
	E — Surface,	34	45	0.03577	2.80
	Bottom,	34	45	0.03577	2.80
	F — Surface,	34	45	0.03270	3.10
	B — Mid-depth (filtrate, sediment),	34	17	0.00463	22.00
May 2,	Inlet, surface,	56	50	0.00628	16.00
	A — Surface,	56	50	0.02120	4.70
	Bottom,	56	50	0.01963	5.10
	B — Surface,	56	50	0.01727	5.80
	Mid-depth,	56	50	0.01649	6.10
	Bottom,	56	50	0.01727	5.80
	C_1 — Surface,	56	50	0.01963	5.10
	Mid-depth,	56	50	0.01884	5.30
	Bottom,	56	50	0.02277	4.40
	C_2 — Surface,	56	50	0.02042	4.90
	Mid-depth,	56	50	0.01963	5.10
	Bottom,	56	50	0.02042	4.90
	C_3 — Surface,	56	50	0.01806	5.50
	Bottom,	56	50	0.01806	5.50
	D — Surface,	56	50	0.01649	6.10
	Bottom,	56	50	0.01884	5.30
	E — Surface,	56	50	0.01570	6.40
	Bottom,	56	50	0.01649	6.10
	F — Surface,	56	50	0.01649	6.10
	A — Mid-depth (filtrate, sediment),	56	13	0.01209	8.30
29,	Inlet, surface,	83	50	0.01256	8.00
	A — Surface,	83	50	0.01256	8.00
	Bottom,	83	50	0.00864	12.00
	B — Surface,	83	50	0.01335	7.50
	Bottom,	83	50	0.00864	12.00
	C_2 — Surface,	83	50	0.00942	11.00
	Bottom,	83	36	0.00872	12.00
	D — Surface,	83	50	0.00942	11.00
	Bottom,	83	50	0.01178	8.50
	F — Surface,	83	50	0.01413	7.00
	Overflow,	83	50	0.01021	9.80
	A — Mid-depth (filtrate, sediment),	83	14	0.00840	12.00

Quincy Reservoir.— Table showing Results of Copper Analyses— Concluded.

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.
1905.					
July 7,	Inlet, surface,	122	50	0.00393	25.00
	A — Surface,	122	50	0.00471	21.00
	B — Surface,	122	50	0.00471	21.00
	Bottom,	122	50	0.00864	12.00
	C_2 — Surface,	122	50	0.00393	25.00
	Bottom,	122	50	0.00864	12.00
	D — Surface,	122	50	0.00550	18.00
	Bottom,	122	50	0.00550	18.00
	F — Surface,	122	50	0.00393	25.00
Aug. 3,	Inlet, surface,	149	50	0.00471	21.00
	A — Surface,	149	50	0.00628	16.00
	B — Surface,	149	50	0.00550	18.00
	Bottom,	149	50	0.00864	12.00
	C_2 — Surface,	149	50	0.00550	18.00
	Bottom,	149	50	0.00314	32.00
	D — Surface,	149	50	0.00314	32.00
	Bottom,	149	50	0.00628	16.00
	F — Surface,	149	50	0.00393	25.00
30,	Inlet, surface,	176	50	0.01649	6.10
	A — Surface,	176	50	0.00471	21.00
	Bottom,	176	50	0.00471	21.00
	B — Surface,	176	50	0.00550	18.00
	Bottom,	176	50	0.00471	21.00
	C_2 — Surface,	176	36	0.00762	13.00
	Bottom,	176	36	0.00546	18.00
	D — Surface,	176	36	0.00326	31.00
	Bottom,	176	50	0.00393	25.00
	F — Surface,	176	36	0.00326	31.00
Oct. 18,	Inlet, surface,	225	50	0.00393	25.00
	A — Surface,	225	50	0.00393	25.00
	Bottom,	225	50	0.00314	32.00
	B — Surface,	225	50	0.00314	32.00
	Bottom,	225	50	0.00393	25.00
	C_2 — Surface,	225	50	0.00314	32.00
	Bottom,	225	36	0.00436	23.00
	D — Surface,	225	50	0.00314	32.00
	Bottom,	225	50	0.00314	32.00
	F — Surface,	225	50	0.00471	21.00

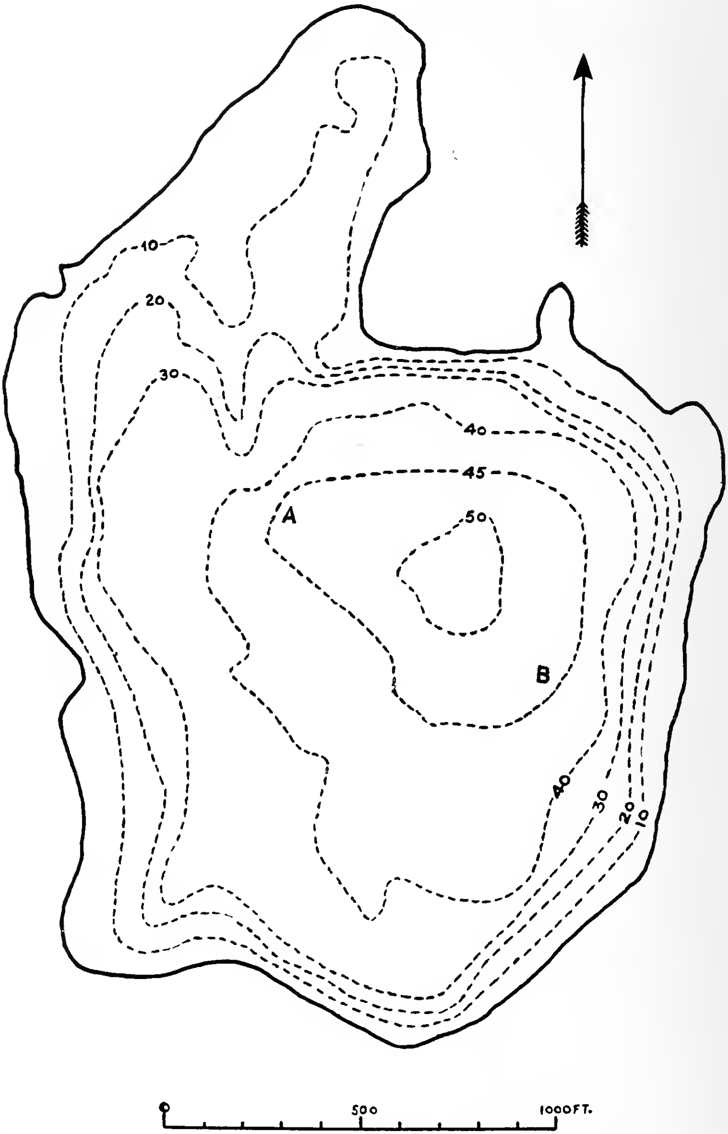
Quincy Reservoir. — Table showing Amount of Copper Sulphate in the Reservoir at Various Times during the Year 1905, expressed in Million Parts of Water to One Part of Copper Sulphate.

	March 7, 12 M.	March 7.	March 7, 4 P.M.	March 8.	March 10.	March 14.	March 22.		April 10.	May 2.	May 29.	July 7.	August 3.	August 30.	October 18.
Days after last treatment,	-	-	-	1	3	7	15	-	34	56	83	122	149	176	225
Station.															
Inlet, surface,	-	Treatment at point between inlet and A with 1,500 pounds copper sulphate, equivalent to 1 part copper to 1,000,000 parts water. Copper dissolved through hole in ice which covered reservoir at this time.	38.0	59.0	38.0	59.0	-	Ice left reservoir.	29.0	16.0	8.0	25.0	21.0	6.1	25.0
A — Surface,	*		38.0	19.0	59.0	77.0	116.0		3.0	4.7	8.0	21.0	16.0	21.0	25.0
Bottom,	*		.025	6.4	29.0	5.7	19.0		3.4	5.1	12.0	-	-	21.0	32.0
B — Surface,	-		13.0	38.0	116.0	90.0	116.0		3.0	5.8	7.5	21.0	18.0	18.0	32.0
Mid-depth,	-		116.0	116.0	*	90.0	-		2.6	6.1	-	-	-	-	-
Bottom,	-		59.0	59.0	116.0	1.5	5.7		2.8	5.8	12.0	12.0	12.0	21.0	25.0
C_1 — Surface,	-		38.0	45.0	116.0	*	116.0		3.0	5.1	-	-	-	-	-
Mid-depth,	-		59.0	-	*	-	-		3.0	5.3	-	-	-	-	-
Bottom,	-		116.0	116.0	14.0	-	-		2.7	4.4	-	-	-	-	-
C_2 — Surface,	*		116.0	38.0	116.0	45.0	59.0		2.7	4.9	11.0	25.0	18.0	13.0	32.0
Mid-depth,	-		59.0	116.0	59.0	45.0	-		2.9	5.1	-	-	-	-	-
Bottom,	*		90.0	*	116.0	45.0	-		2.8	4.9	12.0	12.0	32.0	18.0	23.0
C_3 — Surface,	-		38.0	59.0	90.0	45.0	*		2.7	5.5	-	-	-	-	-
Bottom,	-		7.7	*	116.0	-	-		2.7	5.5	-	-	-	-	-
D — Surface,	-		116.0	59.0	116.0	45.0	116.0		2.9	6.1	11.0	18.0	32.0	31.0	32.0
Bottom,	-		59.0	*	116.0	45.0	59.0		2.6	5.3	8.5	18.0	16.0	25.0	32.0
E — Surface,	*		-	-	-	-	-		2.8	6.4	-	-	-	-	-
Bottom,	32.0		-	-	-	-	-		2.8	6.1	-	-	-	-	-
F — Surface,	-		-	-	-	-	-		3.1	6.1	7.0	25.0	25.0	31.0	21.0

* No copper present.

JAMAICA POND.

Jamaica Pond is a natural reservoir, used for many years as a source of public water supply but abandoned for this purpose in 1892. It has



JAMAICA POND.

NOTE. — Contours show lines of equal depth in feet below full pond.

an area of about 69 acres and a capacity of about 600,000,000 gallons. The maximum depth is 57 feet and the average depth 27 feet. In one of the coves the water is somewhat shallow, but over the remainder of the area the water is deep, and the shores are of clean gravel and sand. The bottom, however, is apparently covered with mud over much of the area. Its drainage area is 467 acres, or .73 of a square mile.

The water of this source has been affected by growths of the organism *Oscillaria,* which have appeared from time to time for many years. The organism does not grow in abundance in every year, but usually in every other year. In 1903 it appeared early in the season and increased to excessive numbers early in May, diminishing to insignificant numbers in July, but again increasing rapidly. The growth in the latter part of the year did not attain the proportions expected, but it was determined to treat the pond with copper sulphate to remove such growth as was present.

About 1,200 pounds of copper sulphate were applied to the reservoir on September 24, this quantity being equivalent to 1 part of copper sulphate in about 4,200,000 parts of water. Four days later a barrel of lime was added, with a view to precipitating the copper sulphate. After this treatment the *Oscillaria* diminished in numbers and soon disappeared from the water.

The condition of the pond was carefully observed throughout the year 1904, but no experiments were made. *Oscillaria* were present in considerable numbers in the early spring, but subsequently disappeared, reappearing again late in September and attaining a large growth in the early part of November.

In 1905 the organism again appeared in the early spring, but subsequently the numbers greatly diminished and the organism disappeared early in May. It reappeared again the latter part of July, and the numbers increased rapidly, and on August 19 the reservoir was treated with copper sulphate in a quantity amounting to 1 part in 1,800,000 parts of water, this requiring 2,400 pounds of the chemical. After the application of the copper sulphate the *Oscillaria* rapidly diminished in numbers and disappeared toward the end of September, and during October and November the water was practically free from organisms.

Analyses to determine the quantity of copper present in this water were first made on July 11, 1904. At this time no copper was found in the water, but a considerable quantity was found in the mud from the bottom of the pond. Later examinations in September and November of this year showed the presence of copper in small quantities in the water, both at the surface and at the bottom of the pond.

Jamaica Pond, as already stated, has a maximum depth of 57 feet.

Stratification of the water takes place in the spring, and the temperature of the water in the bottom of the pond remains throughout the summer at approximately 50° F. The water in the lower layers becomes stagnant and devoid of oxygen, and its odor is offensive. In the fall, as the surface water cools to the temperature of the lower layers, the water circulates to greater depths, and full circulation is established usually near the end of October. This condition has been observed many times and evidently occurs in every year.

At the time of the treatment, on Aug. 19, 1905, two sampling stations were established and samples of water were collected at the surface at each station and at depths of 15 feet, 30 feet and 45 feet, and the quantity of copper at each level and at both stations was determined at frequent intervals during the remainder of the year. The results of the analyses show that when copper sulphate was applied to this pond it remained concentrated in the upper layers, gradually diffusing to a depth of 15 feet, and then very slowly to greater depths, until the temperature of the surface water had fallen to approximately that of the lower layers and the pond "turned over." This happened in the year 1905 in the latter part of October or early in November, and the samples collected on November 8 show for the first time a fairly even distribution of the copper throughout the water.

When the copper sulphate was applied to this pond the fish began to come to the surface, and afterwards large numbers of them were picked up dead along the shores. They apparently continued to die until about August 22, five days after the copper sulphate was applied. All kinds of fish were affected, but the greater number killed were so-called suckers, ranging from 10 to 20 inches in length. Several bass were found, one of which was said to weigh as much as 5 pounds. Many small fish of the variety known as "fresh-water smelts" also died, and a few of other kinds.

The quantity of copper present in the water of Jamaica Pond, together with the numbers of the principal organisms present and the chemical analyses of the water, will be found in the following tables.

Chemical Examinations of Water from Jamaica Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1903.																
45100	Apr. 26	Slight.	Cons.	.02	Faintly vegetable and unpleasant.	Distinctly vegetable and unpleasant.	7.00	2.20	.0008	.0610	.0135	.0475	.78	.0170	.0004	.19	3.0
45507	May 25	Decided.	Cons.	.06	Faintly grassy.	Distinctly grassy.	7.15	2.15	.0010	.1520	.0300	.1220	.83	.0000	.0000	.22	3.1
45600	June 1	Decided.	Cons., scum.	.12	None.	None.	7.25	1.85	.0018	.1540	.0290	.1250	.80	.0000	.0000	.25	3.3
45830	June 16	V. slight.	Cons., scum.	.05	Faintly vegetable, organisms.	Distinctly vegetable, organisms.	6.95	2.20	.0116	.0424	.0256	.0168	.78	.0000	.0003	.22	3.0
46018	June 29	Decided.	Cons.	.05	Faintly vegetable.	Distinctly vegetable and sweetish.	7.25	2.15	.0002	.0414	.0288	.0126	.79	.0010	.0000	.23	2.9
46243	July 13	V. slight.	V. slight.	.07	Faintly vegetable.	Distinctly vegetable.	7.45	2.00	.0024	.0264	.0240	.0024	.79	.0000	.0000	.22	2.7
46455	July 27	Slight.	Slight.	.02	None.	Faintly vegetable.	7.00	1.90	.0036	.0298	.0272	.0026	.76	.0000	.0000	.25	2.2
46705	Aug. 11	Slight.	Cons., scum.	.05	Distinctly grassy, organisms.	Decidedly grassy, organisms.	7.25	1.85	.0010	.0422	.0244	.0178	.80	.0000	.0001	.24	3.0
46900	Aug. 24	Slight.	Cons., scum.	.05	Faintly grassy.[1]	Distinctly unpleasant.[1]	7.05	1.90	.0004	.0770	.0356	.0414	.80	.0000	.0000	.29	2.9
47087	Sept. 8	Slight.	Cons., scum, organisms.	.06	V. faintly unpleasant.	Distinctly sweetish, organisms.	6.55	2.10	.0012	.0800	.0324	.0476	.80	.0030	.0000	.24	2.6
	1904.																
49303	Apr. 26	V. slight.	Cons.	.03	Faintly vegetable.	Distinctly vegetable, geranium.	6.60	2.05	.0042	.0256	.0154	.0102	.77	.0270	.0007	.27	3.1
49393	May 9	Slight.	Cons.	.04	Distinctly vegetable and unpleasant, decaying organisms.	Distinctly vegetable and unpleasant, decaying organisms.	7.30	2.40	.0036	.0308	.0206	.0102	.78	.0220	.0011	.21	3.1

[1] *Oscillaria.*

Chemical Examinations of Water from Jamaica Pond — Continued.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
										Albuminoid.							
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1904.																
49509	May 23	Slight.	Cons.	.03	Distinctly unpleasant, decaying organisms.	Distinctly unpleasant, decaying organisms.	6.65	2.20	.0012	.0268	.0158	.0110	.77	.0270	.0007	.17	3.3
49625	June 6	Slight.	Slight.	.04	Faintly unpleasant.	Faintly unpleasant.	7.20	2.50	.0062	.0248	.0236	.0012	.80	.0210	.0006	.23	3.3
49758	June 22	Slight.	Slight.	.04	Faintly unpleasant.	Faintly unpleasant.	6.90	1.80	.0056	.0246	.0232	.0014	.81	.0200	.0005	.19	3.4
49834	June 27	V. slight.	Slight.	03	V. faintly vegetable.	V. faintly vegetable.	7.05	1.75	.0038	.0268	.0246	.0022	.81	.0200	.0004	.26	3.3
50015	July 7	V. slight.	Slight.	.00	Faintly unpleasant.	Faintly unpleasant.	7.15	2.40	.0052	.0262	.0242	.0020	.82	.0160	.0003	.20	3.3
50058	July 11	V. slight.	Slight.	.01	None.	V. faintly unpleasant.	7.15	2.10	.0048	.0288	.0240	.0048	.84	.0150	.0006	.19	3.3
50204	July 18	Slight.	Cons., green, organisms.	.05	Faintly vegetable.	Distinct of corn silk.[1]	6.85	1.75	.0042	.0250	.0192	.0058	.83	.0160	.0008	.18	3.1
50362	July 25	V. slight.	Cons., green, organisms.	.05	V. faintly unpleasant.	V. faintly unpleasant.	7.25	2.00	.0036	.0306	.0220	.0086	.81	.0110	.0007	.20	3.1
50468	Aug. 1	V. slight.	Cons., green, organisms.	.04	Distinct of corn silk.[1]	Distinct of corn silk.[1]	7.25	1.90	.0040	.0360	.0232	.0128	.80	.0030	.0009	.14	3.1
50683	Aug. 12	V. slight.	Cons., organisms.	.02	Faintly vegetable.	Distinctly vegetable and unpleasant.	7.05	2.30	.0018	.0314	.0222	.0092	.83	.0020	.0001	.26	3.3
50765	Aug. 17	Slight.	Cons.	.01	Faintly unpleasant.	Faintly unpleasant.	7.25	1.75	.0014	.0250	.0212	.0038	.82	.0020	.0000	.17	3.0
50842	Aug. 22	V. slight.	V. slight.	.01	Faintly unpleasant.	Faintly unpleasant.	6.85	1.60	.0236	.0236	.0204	.0032	.82	.0050	.0000	.19	3.3
50948	Aug. 29	Slight.	Slight.	.01	None.	V. faintly unpleasant.	7.20	2.05	.0008	.0260	.0218	.0042	.83	.0020	.0000	.24	3.1
51075	Sept. 6	V. slight.	Slight.	.01	Faintly unpleasant.	Faintly unpleasant.	6.65	1.90	.0004	.0216	.0188	.0028	.82	.0020	.0001	.23	3.0
51119	Sept. 7	V. slight.	V. slight.	.01	Faintly unpleasant, decaying organisms.	Distinctly unpleasant, decaying organisms.	6.55	1.35	.0000	.0200	.0166	.0034	.83	.0060	.0001	.19	2.9
51231	Sept. 14	V. slight.	Slight.	.02	Faintly vegetable.	Distinctly vegetable.	6.80	1.70	.0004	.0238	.0184	.0054	.83	.0020	.0000	.20	3.1

51338	Sept. 21	V. slight.	Slight.	.04	None.	Faintly vegetable.	6.45	1.35	.0008	.0260	.0216	.0044	.82	.0010	.0001	.20	3.3
51477	Sept. 29	V. slight.	Cons.	.03	Faintly unpleasant.	Faintly unpleasant.	7.10	2.00	.0010	.0284	.0198	.0086	.82	.0020	.0000	.20	3.0
51560	Oct. 5	V. slight.	Cons.	.00	None.	None.	6.90	2.00	.0006	.0260	.0208	.0052	.82	.0010	.0000	.18	2.9
51621	Oct. 10	V. slight.	Cons.	.02	Faintly unpleasant.	Distinctly unpleasant.	6.85	1.65	.0012	.0286	.0204	.0082	.82	.0020	.0000	.23	3.0
51707	Oct. 17	V. slight.	Cons.	.02	Faintly unpleasant.	Faintly unpleasant.	6.70	1.95	.0004	.0302	.0210	.0092	.83	.0050	.0001	.24	3.3
51868	Oct. 24	V. slight.	Cons.	.02	None.	None.	6.50	1.70	.0014	.0376	.0246	.0130	.82	.0020	.0000	.20	3.3
51924	Nov. 1	V. slight.	Cons.	.02	None.	None.	6.70	2.15	.0012	.0312	.0214	.0098	.81	.0020	.0000	.18	3.0
51972	Nov. 4	V. slight.	Cons.	.00	V. faintly vegetable.	V. faintly vegetable.	6.65	2.30	.0008	.0276	.0156	.0120	.80	.0010	.0001	.18	3.0
51995	Nov. 7	V. slight.	Cons.	.02	None.	Faintly unpleasant.	6.70	1.65	.0078	.0404	.0264	.0140	.81	.0050	.0000	.21	3.3
52071	Nov. 14	Slight.	Cons.	.04	None.	Faintly vegetable.	7.05	1.75	.0120	.0374	.0226	.0148	.80	.0050	.0000	.34	2.9
52175	Nov. 21	Slight.	Cons.	.09	None.	Faintly unpleasant.	6.80	1.35	.0100	.0408	.0202	.0206	.84	.0010	.0000	.22	3.3
52309	Nov. 28	V. slight.	Cons.	.01	Faintly unpleasant, organisms.	Distinctly unpleasant, organisms.	6.80	1.85	.0080	.0336	.0164	.0172	.82	.0000	.0000	.17	3.3
52338	Dec. 5	V. slight.	Cons.	.08	None.	Faintly vegetable and unpleasant.	6.70	2.10	.0076	.0348	.0148	.0200	.80	.0010	.0000	.17	3.1
	1905.																
53859	Apr. 25	V. slight.	Cons., also scum.	.06	V. faintly vegetable.	Faintly vegetable.	5.00	1.65	.0084	.0368	.0214	.0154	.79	.0110	.0001	.20	3.1
53977	May 3	Slight.	Slight.	.03	None.	V. faintly vegetable.	7.05	2.20	.0166	.0260	.0226	.0034	.81	.0120	.0004	.17	3.0
54314	May 18	V. slight.	Slight.	.05	Faintly unpleasant.	Distinctly unpleasant.	7.50	2.00	.0136	.0236	.0198	.0038	.79	.0010	.0004	.20	3.0
54615	June 7	V. slight.	Cons.	.10	None.	Faintly unpleasant.	7.05	1.75	.0158	.0290	.0236	.0054	.81	.0040	.0003	.23	3.0
54694	June 13	Decided.	Cons.	.09	Faintly unpleasant.	Distinctly unpleasant.	6.75	2.30	.0032	.0368	.0196	.0172	.82	.0090	.0000	.24	2.9
55206	July 10	V. slight.	Cons.	.11	V. faintly unpleasant.	V. faintly unpleasant.	7.30	2.35	.0016	.0364	.0298	.0066	.84	.0040	.0001	.31	2.9
55471	July 24	V. slight.	Cons.	.05	None.	Faintly vegetable.	6.85	1.90	.0040	.0330	.0252	.0078	.86	.0030	.0001	.20	3.0
55893	Aug. 7	Slight.	Slight, organisms.	.05	Faintly vegetable.	Faintly vegetable and unpleasant.	7.30	2.25	.0052	.0292	.0216	.0076	.87	.0010	.0002	.23	3.1
-	Aug. 18	-	-	.11	- -	- -	7.13	1.94	.0741	.0263	.0197	.0066	.83	.0005	.0003	.23	3.3
-	Aug. 21	-	-	.13	- -	- -	6.93	1.60	.0923	.0246	.0186	.0060	.84	.0069	.0002	.23	3.0

[1] *Anabæna.*

Chemical Examinations of Water from Jamaica Pond — Concluded.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1905.																
56300	Aug. 22	Slight.	V. slight.	.08	V. faintly unpleasant.	Faintly unpleasant.	7.45	2.15	.0062	.0298	.0246	.0052	.89	.0030	.0002	.19	3.3
-	Aug. 28	-	-	.15	- -	- -	7.04	1.83	.1127	.0303	.0217	.0086	.84	.0016	.0001	.23	3.0
56516	Sept. 5	V. slight.	V. slight.	.04	V. faintly unpleasant.	Faintly unpleasant.	6.60	1.45	.0114	.0262	.0214	.0048	.85	.0010	.0002	.22	2.9
-	Sept. 7	-	-	.09	- -	- -	6.99	2.01	.0970	.0233	.0182	.0051	.83	.0029	.0003	.19	3.3
56839	Sept. 19	V. slight.	None.	.05	None.	None.	7.35	2.00	.0130	.0266	.0240	.0026	.86	.0030	.0002	.16	3.3
-	Sept. 20	-	-	.07	- -	- -	7.29	2.00	.0804	.0267	.0187	.0080	.87	.0009	.0002	.20	3.1
-	Oct. 3	-	-	.08	- -	- -	7.06	2.05	.0717	.0264	.0199	.0065	.83	.0030	.0000	.21	3.1
57495	Oct. 16	V. slight.	V. slight.	.00	None.	Faintly vegetable.	7.20	2.10	.0028	.0246	.0238	.0008	.86	.0020	.0000	.22	3.1
-	Oct. 23	-	-	.08	- -	- -	7.08	1.84	.1256	.0255	.0187	.0068	.83	.0014	.0001	.21	3.0
57744	Oct. 30	V. slight.	Slight.	.04	Faintly unpleasant.	Distinctly unpleasant.	7.00	1.85	.0106	.0294	.0238	.0056	.86	.0010	.0001	.21	3.0
-	Nov. 8	-	-	.11	- -	- -	7.03	1.96	.0459	.0277	.0209	.0068	.84	.0014	.0001	.20	3.0
58090	Nov. 13	Slight.	V. slight.	.12	Faintly unpleasant.	Faintly unpleasant.	7.20	2.00	.0404	.0358	.0282	.0076	.85	.0010	.0001	.23	3.0
58323	Nov. 27	Decided, green.	Cons., green.	.10	Faintly vegetable and unpleasant.	Distinctly vegetable and unpleasant.	7.10	1.85	.0356	.0368	.0262	.0106	.88	.0020	.0002	.20	3.0

Jamaica Pond.— Table showing Number of Principal Organisms per Cubic Centimeter.

	1903.												
	April 26.	May 25.	June 1.	June 16.	June 29.	July 13.	July 27.	August 11.	August 24.	September 8.	September 21.	September 24.	September 28.
Number of samples,	1	1	1	1	1	1	1	1	1	1	1	-	4
Diatomaceæ:—												Treatment: 1 part copper sulphate to 4,200,000 parts of water.	
Asterionella,	24	0	0	0	0	0	0	0	0	0	0		0
Synedra,	68	30	10	4	2	0	176	4	2	10	6		0
Cyanophyceæ:—													
Anabæna,	0	0	0	0	0	0	0	0	0	0	0		0
Aphanizomenon,	3,336	0	0	0	0	0	0	0	0	0	0		0
Oscillaria,	2	18,200	13,360	1,824	1,056	36	370	1,216	5,816	3,410	2,784		1,850
Algæ:—													
Protococcus,	0	0	0	0	0	84	54	26	0	0	0		0
Infusoria:—													
Ceratium,	0	0	0	2	0	2	10	6	76	10	4		0
Dinobryon,	0	0	0	0	0	0	0	0	0	0	0		0
Monas,	0	0	0	2	0	0	0	0	0	0	0		0
Uroglena,	0	0	0	0	0	0	0	0	0	0	0		0
Total organisms,	3,470	18,323	13,376	1,862	1,098	131	645	1,262	5,908	3,440	2,764		1,856

Jamaica Pond.— Table showing Number of Principal Organisms per Cubic Centimeter — Continued.

	1904.																
	April 26.	May 9.	May 23.	June 3.	June 6.	June 16.	June 22.	June 27.	July 7.	July 11.	July 14.	July 18.	July 25.	August 1.	August 17.	August 22.	August 29.
Number of samples,	1	1	1	4	1	4	1	1	1	1	4	1	1	1	1	1	1
Diatomaceæ:—																	
Asterionella,	9,072	6,708	512	19	0	217	36	41	21	12	7	0	0	0	0	0	0
Synedra,	244	244	34	2	0	*	0	1	0	2	0	0	4	39	36	31	35
Cyanophyceæ:—																	
Anabæna,	0	0	0	0	0	0	0	0	0	0	0	52	4	45	0	2	3
Aphanizomenon,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oscillaria,	34	60	30	0	0	0	0	0	0	2	2	0	0	0	1	0	0
Algæ:—																	
Protococcus,	0	4	28	41	0	1,292	352	647	740	1,324	2,632	8,920	8,000	6,952	5,730	3,170	4,570
Infusoria:—																	
Ceratium,	0	0	0	0	1	*	4	14	4	1	*	4	2	1	0	0	1
Dinobryon,	276	40	0	0	1	*	4	14	4	1	*	4	0	1	0	0	0
Monas,	216	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Uroglena,	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total organisms,	9,992	7,182	722	94	14	1,526	403	712	775	1,359	2,662	8,984	8,024	7,054	5,774	3,210	4,621

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Jamaica Pond. — *Table showing Number of Principal Organisms per Cubic Centimeter* — Continued.

	1904.																	
	September 6.	September 7 (Surface).	September 7 (Bottom).	September 14.	September 21.	September 29.	October 5.	October 10.	October 17.	October 24.	November 1.	November 4 (Surface).	November 4 (Bottom).	November 7.	November 14.	November 21.	November 28.	December 5.
Number of samples,	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Diatomaceæ:—																		
Asterionella,	0	0	0	0	0	0	0	0	14	3	6	16	8	4	10	1	2	26
Synedra,	62	60	2	24	26	36	11	8	18	5	2	6	0	10	6	5	0	6
Cyanophyceæ:—																		
Anabæna,	1	0	0	3	0	2	0	1	0	1	2	0	0	3	0	0	0	0
Aphanizomenon,	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Oscillaria,	3	12	440	43	71	71	93	196	384	530	548	606	412	534	682	626	824	1,224
Algæ:—																		
Protococcus,	2,080	3,180	262	2,280	1,040	568	670	570	242	79	96	80	22	11	35	4	30	0
Infusoria:—																		
Ceratium,	1	4	1	3	1	0	2	2	0	0	0	2	0	0	0	0	0	0
Dinobryon,	1	2	1	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
Uroglena,	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total organisms,	2,156	3,267	716	2,404	1,207	699	789	812	677	653	682	749	460	584	757	665	894	1,274

Jamaica Pond.— Table showing Number of Principal Organisms per Cubic Centimeter— Continued.

	1905.														
	March 28.	April 14.	April 25.	May 3.	May 12.	May 18.	June 2.	June 7.	June 13.	June 22.	July 5.	July 10.	July 17.	July 24.	July 26.
Number of samples,	4	2	1	1	2	1	2	1	1	2	2	1	2	1	2
Diatomaceæ:—															
Asterionella,	0	0	0	233	1,112	58	*	2	0	0	0	0	0	0	0
Synedra,	*	5	4	0	214	184	1,093	16	12	0	0	0	*	8	0
Cyanophyceæ:—															
Anabæna,	0	0	0	0	0	0	0	0	0	0	0	1	4	6	1
Aphanizomenon,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oscillaria,	5,374	610	662	12	1	8	*	0	0	0	0	0	0	0	3
Algæ:—															
Protococcus,	0	0	4	0	0	0	17	146	2,496	1,942	612	108	3,270	3,536	2,912
Infusoria:—															
Ceratium,	0	0	0	0	0	0	*	0	0	0	4	1	14	0	0
Dinobryon,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uroglena,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total organisms,	5,378	635	672	247	1,351	256	1,121	173	2,654	2,006	1,082	389	3,301	3,562	2,920

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Jamaica Pond. — Table showing Number of Principal Organisms per Cubic Centimeter — Continued.

	1905.														
	August 7.	August 14.	August 18.	August 18 (15 Feet).	August 18 (30 Feet).	August 18 (45 Feet).	August 19.	August 21.	August 21 (15 Feet).	August 21 (30 Feet).	August 21 (45 Feet).	August 22.	August 23.	August 28.	August 28 (15 Feet).
Days after last treatment,	–	–	–	–	–	–	–	2	2	2	2	3	4	9	9
Number of samples,	1	2	2	2	2	2	–	2	2	2	2	2	2	2	2
Diatomaceæ:—							Treatment: 1 part copper sulphate to 1,800,000 parts water.								
Asterionella,	0	0	0	0	0	0		0	2	0	0	0	0	0	0
Synedra,	0	0	0	0	0	0		0	0	0	6	3	1	2	1
Cyanophyceæ:—															
Anabæna,	0	0	2	2	2	0		8	2	0	0	7	10	14	15
Aphanizomenon,	0	0	0	0	0	0		0	0	0	0	0	0	0	0
Oscillaria,	248	760	618	512	10	8		723	240	6	4	542	422	601	693
Algæ:—															
Protococcus,	856	1,760	498	570	166	130		0	0	0	0	*	0	64	50
Infusoria:—															
Ceratium,	0	4	2	2	0	0		1	6	0	2	0	1	0	0
Dinobryon,	0	0	0	0	0	0		0	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0		0	0	8	2	0	0	0	0
Uroglena,	0	0	0	0	0	0		0	0	0	0	0	0	0	0
Total organisms,	1,108	2,547	1,132	1,102	196	150		740	256	34	31	671	436	684	761

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Jamaica Pond.— Table showing Number of Principal Organisms per Cubic Centimeter— Continued.

	1905.													
	August 28 (30 Feet).	August 28 (45 Feet).	September 5.	September 7.	September 7 (15 Feet).	September 7 (30 Feet).	September 7 (45 Feet).	September 19.	September 20.	September 20 (15 Feet).	September 20 (30 Feet).	September 20 (45 Feet).	September 26.	October 3.
Days after last treatment,	9	9	17	19	19	19	19	31	32	32	32	32	38	45
Number of samples,	2	2	1	2	2	2	2	1	2	2	2	2	2	3
Diatomaceæ:—														
Asterionella,	0	110	0	0	0	0	1	0	0	0	1	1	0	0
Synedra,	*	160	0	2	0	*	1	1	0	0	7	3	0	0
Cyanophyceæ:—														
Anabæna,	1	0	2	*	*	0	0	0	0	0	0	0	0	0
Aphanizomenon,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oscillaria,	23	8	94	80	42	3	0	74	32	34	3	0	2	1
Algæ:—														
Protococcus,	34	28	0	0	0	0	0	0	0	0	0	0	5	0
Infusoria:—														
Ceratium,	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monas,	2	6	0	0	0	4	0	17	0	0	0	0	1	1
Uroglena,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total organisms,	83	372	97	88	50	20	7	102	38	47	43	23	51	7

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Jamaica Pond. — *Table showing Number of Principal Organisms per Cubic Centimeter* — Concluded.

	1905.												
	October 3 (15 Feet).	October 3 (30 Feet).	October 3 (45 Feet).	October 16.	October 26.	October 26 (15 Feet).	October 26 (30 Feet).	October 26 (45 Feet).	October 30.	November 8.	November 8 (15 Feet).	November 8 (30 Feet).	November 8 (45 Feet).
Days after last treatment,	45	45	45	58	68	68	68	68	72	81	81	81	81
Number of samples,	2	2	2	1	2	2	2	2	1	2	2	2	2
Diatomaceæ:—													
Asterionella,	0	0	1	0	0	*	1	*	2	1	1	1	43
Synedra,	0	6	4	4	0	0	0	3	0	0	0	*	11
Cyanophyceæ:—													
Anabæna,	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphanizomenon,	0	0	0	0	0	0	0	0	0	0	0	0	0
Oscillaria,	0	*	0	0	0	*	1	0	0	0	0	0	0
Algæ:—													
Protococcus,	0	0	0	0	0	0	0	0	0	0	0	0	0
Infusoria:—													
Ceratium,	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	0	0	0	0	0	0	0	0	0
Monas,	1	0	*	7	21	20	*	0	9	0	1	1	0
Uroglena,	0	0	0	0	0	0	0	0	0	0	0	0	0
Total organisms,	9	29	18	14	27	31	38	10	55	52	87	84	286

* The organism was present in some samples but not in others, the average number of organisms being less than 1.

Jamaica Pond.— Table showing Results of Copper Analyses.

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Parts Copper Sulphate to 100,000 Parts Water.	Million Parts Water to 1 Part Copper Sulphate.
1904.					
July 11,	-	-	15	.00000	*
Sept. 7,	Surface,	-	50	.00393	26.00
	Bottom,	-	50	.00236	42.00
Nov. 4,	Surface,	-	50	.00157	64.00
	Bottom,	-	50	.00314	32.00
1905.					
Aug. 17,	B — 0,	-	50	.00157	64.00
	15,	-	50	.00000	*
	30,	-	50	.00079	127.00
	45,	-	50	.00079	127.00
18,	A — 0,	-	50	.00157	64.00
	15,	-	50	.00236	42.00
	30,	-	50	.00079	127.00
	45,	-	50	.00157	64.00
19,	Treatment: 2,400 pounds copper sulphate, equivalent to 1 part copper sulphate to 1,800,000 parts water.				
21,	A — 0,	2	50	.08873	1.10
	15,	2	50	.02434	4.10
	30,	2	50	.00314	32.00
	45,	2	50	.00000	*
	B — 0,	2	50	.07381	1.40
	15,	2	36	.03270	3.00
	30,	2	50	.00314	32.00
	45,	2	19	.00209	47.00
28,	A — 0,	9	50	.07459	1.30
	15,	9	50	.05025	2.00
	30,	9	50	.00236	42.00
	45,	9	50	.00236	42.00
	B — 0,	9	50	.07459	1.30
	15,	9	50	.05261	1.90
	30,	9	50	.00393	25.00
	45,	9	50	.00628	16.00
Sept. 7,	A — 0,	19	50	.05418	1.80
	15,	19	50	.05968	1.70
	30,	19	50	.00471	21.00
	45,	19	50	.00550	18.00
	B — 0,	19	36	.05889	1.70
	15,	19	50	.05104	2.00
	30,	19	50	.01178	8.50
	45,	19	50	.00942	10.60
20,	A — 0,	32	50	.03847	2.60
	15,	32	50	.04005	2.50
	30,	32	50	.00707	14.00
	45,	32	50	.00785	13.00
	B — 0,	32	50	.04633	2.20
	15,	32	50	.04319	2.30
	30,	32	50	.01021	9.80
	45,	32	36	.00326	31.00
Oct. 3,	A — 0,	45	50	.02748	3.60
	15,	45	50	.02905	3.40
	30,	45	50	.00785	13.00
	45,	45	50	.00628	16.00
	B — 0,	45	50	.03533	2.80
	15,	45	50	.03062	3.30
	30,	45	50	.00550	18.00
	45,	45	50	.00707	14.00

* No copper present.

Jamaica Pond. — Table showing Results of Copper Analyses — Concluded.

Date.	Location.	Days after Last Treatment.	Water. Quantity examined (Litres).	Water. Parts Copper Sulphate to 100,000 Parts Water.	Water. Million Parts Water to 1 Part Copper Sulphate.
1905.					
Oct. 23, ...	A — 0, . .	65	50	.02670	3.80
	15, . .	65	50	.02827	3.50
	30, . .	65	50	.00707	14.00
	45, . .	65	50	.01099	9.10
	B — 0, . .	65	50	.02277	4.40
	15, . .	65	50	-	-
	30, . .	65	50	.00785	13.00
	45, . .	65	50	.01178	8.50
Nov. 8, ...	A — 0, . .	81	50	.01963	5.10
	15, . .	81	33	.02140	4.70
	30, . .	81	50	.01650	6.10
	45, . .	81	50	.01806	5.50
	B — 0, . .	81	50	.01570	6.40
	15, . .	81	50	.01570	6.40
	30, . .	81	50	.02277	4.40
	45, . .	81	50	.01570	6.40

Jamaica Pond. — Table showing Amount of Copper Sulphate Present in the Pond at Various Times during the Year 1905, expressed in Million Parts of Water to One Part of Copper Sulphate.

	August 17-18.	August 19.	August 21.	August 28.	September 7.	September 20.	October 3.	October 23.	November 8.
Days after last treatment,	-	-	2	9	19	32	45	65	81
Station.		Treatment: 2,400 pounds copper sulphate, equivalent to 1 part copper sulphate to 1,800,000 parts water.							
A — 0, ...	64.0		1.1	1.3	1.8	2.6	3.6	3.8	5.1
15, ...	42.0		4.1	2.0	1.7	2.5	3.4	3.5	4.7
30, ...	127.0		32.0	42.0	21.0	14.0	13.0	14.0	6.1
45, ...	64.0		*	42.0	18.0	13.0	16.0	9.1	5.5
B — 0, ...	64.0		1.4	1.3	1.7	2.2	2.8	4.4	6.4
15, ...	*		3.0	1.9	2.0	2.3	3.3	-	6.4
30, ...	127.0		32.0	25.0	8.5	9.8	18.0	13.0	4.4
45, ...	127.0		47.0	16.0	10.6	31.0	14.0	8.5	6.4

* No copper present.

Observations upon the Results of the Application of Copper Sulphate to Crystal Lake in Newton, under the Direction of the Newton Board of Health.

Crystal Lake is situated in the city of Newton, in a thickly populated district, and is not used as a source of public water supply. Its area is about 31 acres and its storage capacity 143,000,000 gallons. The water-shed is small, probably not exceeding 1 square mile, including the area of the lake.

During the summer of 1905 the water was affected by the presence of very large numbers of *Anabœna,* which caused a nuisance in the neighborhood, and the purpose of the treatment was to obtain relief from the objectionable odor of the lake.

According to the information available, the lake was treated on August 18 with 315 pounds of copper sulphate, equivalent to 1 part of copper sulphate in 4,000,000 parts of water. The numbers of *Anabœna* gradually decreased and had nearly disappeared on September 1.

Samples of water collected on September 1, two weeks after the treatment, showed that this lake becomes stratified in the summer season similarly to Jamaica Pond, and the copper was found concentrated in the upper layers, very little being found in the water near the bottom.

The fish were affected by the application of the copper sulphate, and a number of dead fish was found upon the shores as late as the first of September, two weeks after the copper sulphate was applied.

Massapoag Lake, Sharon.

The lake has an area of 352 acres and is not used as a source of public water supply. The shores and much of the bottom are of coarse gravel and sand, and no aquatic plants were found growing in the lake. The water-shed, which has an area of 3.6 square miles, drains a hilly country with little swamp, and the water does not ordinarily contain an excessive quantity of organic matter, but has considerable color.

The information as to the treatment of this lake is to the effect that 3,600 pounds of copper sulphate were applied early in November, giving an approximate concentration of 1 part of copper sulphate in 5,000,000 parts of water. Copper sulphate was applied for the purpose of destroying *Anabœna,* which are ordinarily present in this water in large numbers. The growth appeared early in the season of 1905, but this organism does not appear to have been present in the early part of October, before the treatment was made. Analyses of the water on November 10 showed that the quantity of copper sulphate present was about 1 part in 5,400,000 parts of water. The quantity varied greatly, however, and was much greater in a sample collected subsequently.

Following the application of copper sulphate the fish died in enormous numbers, it being estimated that 250,000 fish were washed ashore within a few days after the treatment.

Summary.

In these experiments it has been found that when copper sulphate is applied to ponds and reservoirs containing large numbers of organisms it has been effective in removing certain kinds completely, but upon certain other kinds it has had little or no effect.

At Belchertown Reservoir the great numbers of *Anabœna* present in the summer of 1904 disappeared almost completely within a few days after the application of copper sulphate in a quantity equivalent to 1 part in 8,000,000 parts of water. In 1905, after the application of a similar quantity of copper sulphate, the numbers of that organism diminished greatly within a few days, but they subsequently increased very rapidly, until they became greater than ever. A second application of an equal quantity of copper sulphate was followed within a few days by the complete disappearance of all the organisms of this kind.

In Arlington Reservoir the Cyanophyceæ, which were present in 1903 (though in comparatively small numbers), quickly disappeared after the reservoir had been treated with 1 part of copper sulphate in 1,800,000 parts of water. They reappeared in 1904, but disappeared after copper sulphate had been applied in a quantity amounting to 1 part in 3,650,000, and were not found in the water again during that year. They reappeared in 1905, apparently in about the usual numbers.

After the application of copper sulphate to Crystal Lake in Newton, in a quantity amounting to 1 part in 4,000,000 parts of water, the organism *Anabœna,* which was present in great numbers, slowly disappeared.

Oscillaria and others of the Cyanophyceæ, which have appeared from time to time in great numbers in Jamaica Pond, disappeared in 1903 after the application of 1 part of copper sulphate in 4,200,000 parts of water. The organism reappeared in 1904, but not in such great numbers as in the previous year. In 1905 the organism again appeared in great numbers, but disappeared after the application of copper sulphate in a quantity amounting to 1 part in 1,800,000.

These results indicate that the Cyanophyceæ, which are among the most troublesome of the organisms which cause disagreeable tastes and odors in the waters of ponds and reservoirs, can be removed by the application of copper sulphate in a quantity amounting approximately to 1 part of copper sulphate in 4,000,000 to 8,000,000 parts of water.

Among the other most troublesome organisms which affect the waters of ponds and reservoirs are the Infusoria, especially such organisms as

Uroglena and *Synura,* which appear generally in the winter season and often remain for a long period, especially when the reservoirs are covered with ice. Water affected by the presence of such organisms is often rendered unfit for drinking and most other domestic uses. The only opportunity afforded for treating a water affected by either of these organisms was presented by the appearance of *Uroglena* in Lexington Reservoir in June, 1905; and the application of copper sulphate in a quantity sufficient to bring the quantity of copper sulphate in the water up to 1 part in 12,000,000 parts of water was followed by the disappearance of this organism. It should be said, however, that the organism *Uroglena* is very rarely found to be present in great numbers as late as the month of June.

A reservoir affected with *Uroglena* when covered with ice cannot be treated efficiently with copper sulphate, on account of the failure of the copper sulphate to diffuse freely under such conditions, as is shown by the experiments at Lexington and Quincy. Of the effect of copper sulphate upon other Infusoria no information is furnished by these experiments.

Upon the other organisms — the Diatomaceæ and green Algæ — the application of copper sulphate appears in some cases to be unfavorable to their continued development, and in other cases to have little effect.

At Arlington the organism *Staurastrum,* one of the Algæ, grew in great numbers in 1904, and was not affected by the application of copper sulphate in a quantity equivalent to 1 part in 3,650,000 parts of water, but practically disappeared in a little over two weeks upon the application of 1 part of copper in 730,000. *Scenedesmus* and *Protococcus,* on the other hand, were not affected. In general, the treatment of reservoirs containing organic growths of this kind, judging from the results at Arlington, cannot be expected to produce much effect. Moreover, when organisms of one kind are destroyed, other kinds quickly appear and multiply.

While the application of copper sulphate will apparently remove certain organisms from water, the experiments indicate that after repeated treatments of a reservoir for the removal of such organisms larger quantities of copper sulphate may be required. The investigations have not, however, been carried far enough to determine this point definitely.

The experiments have shown that the application of copper sulphate to the water of ponds and reservoirs is likely to have a very injurious effect under some conditions upon fish life in the water; and there is apparently a great variation in the effect of a given quantity of copper upon the fish in different reservoirs, and also in the same reservoir at different times. A quantity of copper sulphate as small as 1 part in

5,000,000 parts of water used in Massapoag Lake at Sharon destroyed enormous numbers of fish; while frequent applications at Arlington Reservoir in such an amount that the quantity of copper sulphate present in the water reached a concentration ten times as great as at Massapoag Lake apparently injured very few of the fish.

Determinations of the quantity of copper present in the waters of different reservoirs at different times after the application of copper sulphate, and especially the results of the experiments upon the diffusion of copper, are of great importance.

In the shallow ponds and reservoirs the diffusion of the copper in summer was found to be very unequal, and for a long period after the copper sulphate had been applied samples containing copper in much greater concentration than applied were sometimes obtained. The reason for this is, apparently, that the copper settles to the bottom, much of it combining with organic matters from which it is set free after their decomposition, and is again diffused through the water by the action of the wind. In deep ponds and reservoirs, such as Jamaica Pond and Crystal Lake, in which circulation ceases in the spring and stratification of the water takes place, so that the bottom layers remain stagnant until late in the fall, the copper sulphate applied remained concentrated in the upper layers of the water for a period of many weeks. In Jamaica Pond the water near the surface contained at this time very little suspended organic matter.

While copper sulphate has been found to be present in varying quantities in the waters of all ponds and reservoirs for a period of several months after treatment, the amount of this chemical gradually diminished on the whole in all of the cases in which the results were carefully followed, and eventually practically disappeared from the water. In Arlington Reservoir, to which copper sulphate was applied in August, 1903, in a quantity amounting to 1 part in 1,800,000, no trace of copper was found in the following July. Great quantities of copper were applied to this reservoir in 1904, but the amount present in the water gradually diminished, and had become very small by the end of the year 1905. A very great increase, however, was noted in the amount of copper present in the mud at the bottom of the reservoir after the application of the large quantities of copper sulphate in 1904.

Copper sulphate is regarded as a poisonous substance when present in food even in very small quantities, and if it should be deemed desirable to apply it to the water of a pond or reservoir used as a source of water supply for domestic purposes, the water should not be used for drinking until possible danger from the presence of copper in the water has passed.

INVESTIGATIONS

IN REGARD TO

THE USE OF COPPER AND COPPER SULPHATE.

THE ABSORPTION AND SEDIMENTATION OF COPPER SULPHATE WHEN USED AS AN ALGICIDE.

Efficiency of Copper and Copper Sulphate as Bactericides, etc., together with a Description of the Method of Chemical Analysis.

By H. W. CLARK, *Chemist of the Board.*

INVESTIGATIONS IN REGARD TO THE USE OF COPPER AND COPPER SULPHATE.

THE ABSORPTION AND SEDIMENTATION OF COPPER SULPHATE WHEN USED AS AN ALGICIDE. EFFICIENCY OF COPPER AND COPPER SULPHATE AS BACTERICIDES, ETC., TOGETHER WITH A DESCRIPTION OF THE METHOD OF CHEMICAL ANALYSIS.

By H. W. Clark, *Chemist of the Board.*

The following report is a description of experimental work upon the use of copper sulphate and metallic copper in the destruction of bacteria, algæ, etc., together with the results of experiments upon sedimentation of copper sulphate, its combination with mineral and organic matters, etc.

REPORT.

When this work was begun there was no known method for the accurate determination of copper in the extreme dilutions used, and the method given below has been worked out in the laboratories of the Board. With the method as described, it is possible for a chemist to complete ten to twelve analyses per week, working during the usual laboratory hours.

Description of Method of determining Copper.

The object of this method is to free the water from organic matter, coloring matter, silicates, iron and other metals except copper, and then to deposit metallic copper in such amounts that it can be weighed. To do this, a considerable quantity of water is concentrated to a small bulk in a porcelain dish, with a little hydrochloric and nitric acid; 5 to 10 cubic centimeters of concentrated sulphuric acid are added, and then the mixture is heated over a lamp until copious fumes of sulphuric acid are given off. The contents of the dish are then diluted with water, boiled and filtered into a beaker, washing with hot water. The filtrate is then neutralized with ammonia, a slight excess of sulphuric acid is added, and then a considerable excess of hydrogen sulphide water; and the beaker is allowed to stand some time, preferably over night. The sulphides are then filtered off and dissolved in nitric acid; concentrated

sulphuric acid is then added, and the dish heated over a lamp until copious fumes of sulphuric acid are given off. The solution is then filtered into a flask, made neutral with ammonia to remove any iron, and again filtered. This filtrate is neutralized with a small amount of sulphuric acid, and concentrated to a small bulk; 10 cubic centimeters of sulphuric acid and 1 gram of urea are added, and then the mixture is electrolyzed in a platinum dish. The dish with the copper coating is dried and weighed, the copper is dissolved off the dish with dilute nitric acid and the dish is dried and weighed again. The difference in weight gives the copper found. To test the method, the following experiment was made: —

A solution of crystallized copper sulphate ($CuSO_4.5H_2O$) was made by dissolving .3926 gram in a liter of water. One cubic centimeter of such a solution contains .0001 milligram copper. In order to standardize this solution, measured portions were electrolyzed, with the following results: —

	Copper taken (Gram).		Copper found (Gram).
	.0043		.0044
	.0096		.0095
Average, ...	.00695	Average, ...	.00695

These results are as nearly correct as it is possible to work; and the strength of the copper solution was taken at its theoretical value in all the following experiments.

Experiments upon Accuracy of Method.

Four portions of standard solution were measured into porcelain dishes and diluted with a considerable quantity of distilled water by one person and carried through the regular process of analysis by a second person. The resulting solutions were electrolyzed and the deposits weighed by a third person. The results are shown in the following table: —

Copper taken (Gram).	Copper found (Gram).	Error (Gram).	Copper taken (Gram).	Copper found (Gram).	Error (Gram).
.0006	.0005	—.0001	.0021	.0019	—.0002
.0009	.0007	—.0002	.0047	.0050	+.0003

To determine the correction to be applied for distilled water and for reagents ordinarily used in the process, the following experiments were made: —

Fourteen liters of distilled water from an ordinary still, which is of tin-lined copper, were concentrated and carried through the regular process. The yield was .0002 gram of copper. Since in the course of analysis not more than 1 liter of distilled water is ever used for washing and other purposes, the correction to be applied for this source of possible error — $\frac{1}{14}$ of .0002 gram — can, of course, be neglected. To determine the reagent correction, the same amounts of reagents as are used ordinarily in the regular process were carried through the process of analysis, and they proved to be free from copper.

Discussion of Results.

Since in the determination of copper in reservoir waters, etc., not more than 50 liters, or 13 gallons, of water are evaporated; and as in these 50 liters there is generally a weight of not more than a few tenths of a milligram of copper, there must be a very small and unavoidable error in weighing, due to the fact that the chemical balances are not sensitive to less than .1 of a milligram. Many laboratory experiments, however, have shown that the method is satisfactory and more accurate than colorimetric methods.

The results of six determinations of known amounts of copper are given in the following table, the amount in solution not being known to the analyst: —

Results of Six Determinations of Known Amounts of Copper.

Experiment Number.	Number of Liters of Water taken.	Copper taken (Gram).	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —	Copper found (corrected) Gram.	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —	Absolute Error (Gram Copper).	Per Cent. Error.	Difference in Equivalent of $CuSO_4.5H_2O$ in (Parts of Water) —
11, . . .	50	.0006	21,226,000	.0008	15,919,500	+.0002	+33.3	5,306,500
12, . . .	50	.0014	9,096,857	.0017	7,491,529	+.0003	+21.4	605,328
13, . . .	34	.00475	1,823,201	.0048	1,804,210	+.00005[1]	+1.0	18,991
14, . . .	34	.0091	951,670	.0085	1,018,848	—.0006	—6.6	67,178
15, . . .	16	.0222	183,576	.0201	202,755	—.0021	—9.4	19,179
16, . . .	16	.0404	100,875	.0360	113,205	—.0044	—10.8	12,330
Blank, . .	25	-	-	.0001	-	-	-	-

[1] This difference is beyond the sensitiveness of the balance.

Copper naturally in Massachusetts Waters.

When this investigation was begun, it was assumed that the natural waters of Massachusetts were free from copper. As the work progressed, it was discovered that the water of some of the reservoirs of the State,

not known to have been treated with copper sulphate, contain copper in minute amounts. This is not surprising, when we consider, first, the fact that small amounts of copper-bearing rock are found in the State; that large amounts of copper salts are used for spraying vegetation; and that the method used for determining copper is capable of detecting almost infinitesimal amounts. Examination of mud from the bottom of reservoirs which had not been treated with copper sulphate showed that small amounts of copper were present in some of the samples.

Destruction of Algæ by Copper Sulphate.

Experiments with Ludlow Reservoir Water in Carboys and Tanks at Ludlow. Copper in Reservoir Water, etc.

Experiments upon the treatment of water containing *Anabœna* were made at Ludlow, beginning Aug. 12, 1904; but these experiments are of little moment, compared with work in reservoirs, tanks, etc., carried on elsewhere. A brief summary of them is, however, given. When this work was begun, it was assumed, as stated, that copper was not naturally present, and examination therefor before the addition of copper sulphate was not made. When the experiments were under way, however, and the first examination made, it was found that in some instances copper was present in the water taken from the carboys and tanks in amounts greater than had been applied. The tanks were filled by means of a pump which was supposed to be entirely of iron, but after these results were obtained it was taken apart and examined, and brass valves were found. It was then assumed that the copper found was taken from these valves while the water was passing through the pump.[1] This was not the only source, however; for examinations made on Nov. 9, 1904, showed that the water from the Jabish Brook canal contained 1 part of copper sulphate in 42,000,000, and that the water of the reservoir contained 1 part in 16,000,000.[2]

Anabœna in the Reservoir Water, and its Coagulation by Copper Sulphate.

On Aug. 12, 1904, water from Ludlow Reservoir was placed in carboys at the reservoir while tanks were being prepared for use. Four carboys were used, and copper sulphate was added to No. 1 at the rate of 1 part in 500,000, to No. 2 at the rate of 1 part in 1,000,000, and

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[1] That copper is readily taken from brass valves and pipes has been shown in other ways, and especially by the examinations of water that has passed through brass piping in the State House, a sample of water that had stood over night in these pipes containing, as shown by analysis, 1 part of copper sulphate in 1 million parts of water; and a sample collected during day-time use containing 1 part in 5.7 million parts of water.

[2] For uniformity, the copper found is in all instances given as copper sulphate.

to No. 3 at the rate of 1 part in 5,000,000. The water in carboy No. 4 was not dosed.

The microscopical analysis of the water taken at this time showed 2,100 *Anabœna* per cubic centimeter. Within two hours the *Anabœna* began to disintegrate in the water in the carboys in which the greater amounts of copper were used, and formed a thin, whitish scum at the surface. The water became turbid, and of a bluish-green color; and it did not clear effectively. In the water to which the smallest amount of copper had been applied the *Anabœna* collected at the surface, leaving the water below clear; and this also occurred in the water in carboy No. 4, which had not been treated with copper sulphate.

At the end of forty-eight hours the water in carboys Nos. 1 and 2 was filtered, the clear water in No. 3 was carefully siphoned off from the *Anabœna,* and both water and *Anabœna* were sent to the laboratory separately for analysis. The analysis of these samples gave the following results: —

Dose.		$CuSO_4.5H_2O$ (Parts per 100,000).	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —
1 part in 500,000	Water,	.11452	670,000
	Anabæna,	.27482	360,000
1 part in 1,000,000	Water,	.07726	1,290,000
	Anabæna,	.20937	480,000
1 part in 5,000,000	Water,	.02528	3,900,000
	Anabæna,	.08000	1,200,000

In each case the *Anabœna* analyzed contained considerable water, it being impossible to free the mass therefrom; but this water was only about one-twelfth of the total volume in each carboy.

Noting the results given in the previous table, it will be seen that about one-fourth of the total amount of copper sulphate used was found in connection with the *Anabœna,* showing that the organisms had collected and carried out of solution a considerable amount of the copper sulphate.

Experiments in Tanks.

On August 23 three tanks, numbered 1, 2 and 3, of a capacity of 550, 1,000 and 1,000 gallons, respectively, and from 5 to 6 feet in depth, were filled with reservoir water and dosed with copper sulphate in the proportions 1 to 1,000,000, 1 to 4,000,000 and 1 to 5,000,000 parts respectively. Microscopical analysis of a sample of water from the tanks, taken before dosing with copper sulphate, showed the presence of 2,768

Anabæna per cubic centimeter. The water in the tanks after dosing acted much as it did in the carboys, turning from green to bluish-green in from two to ten hours, according to the strength of the dose, and becoming very turbid. A thin, white scum formed on the water in all three tanks, but was soon broken up by the wind. The turbidity became densest about forty-eight hours after dosing, and after that time no change was observed in the appearance of the water. In all of these tanks more copper sulphate was added than later experiments showed was necessary, and the *Anabæna,* instead of collecting, had disintegrated.

Samples taken from each tank yielded more copper than had been added; and forty-two days after dosing, samples taken from the surface, middle and bottom of Tank No. 3 yielded the following amounts. The copper, instead of remaining evenly distributed in the water, had settled to some extent.

Tank No. 3.	$CuSO_4.5H_2O$ (Parts per 100,000).	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —
Surface,	.02936	3,400,000
Middle,	.03702	2,700,000
Bottom,	.07628	1,300,000

Tank No. 1 was filled again on August 30, and treated with 1 part copper sulphate in 1,000,000 parts of water. At the end of twenty-four hours, the *Anabæna,* large numbers of which had come to the surface, were filtered from five gallons of the water for analysis. The results of the analysis show that three-fifths of the copper placed in the water had been taken up by the *Anabæna,* and two-fifths left free in the water. In the carboy experiments, from one-fifth to one-fourth only was taken up by the *Anabæna.*

	Actual Weight Copper found.	$CuSO_4.5H_2O$ found (Parts per 100,000).	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —
Filtrate,	.0016	.04833	2,100,000
Anabæna,	.0029	.85595	117,000

On September 16, a tank was filled, using galvanized iron pails instead of the pump, and the water was treated with 1 part copper sulphate to 1,000,000. Microscopical examination of the reservoir water of this day gave 13 filaments of *Anabæna* per cubic centimeter. This

result does not show the real number present, however, as the water contained large numbers of *Anabæna* when the tanks were filled; but the organism was evidently ready to break up, and did so in the sample bottle before it reached the laboratory in Boston. In the water in this tank the filaments disappeared in from eight to ten hours, a pronounced turbidity was produced by their disintegration, and *Anabæna* did not gather at the surface of the water. Samples taken from this tank twenty-four hours, nine days, fifteen days and twenty days after dosing with 1 part copper sulphate in 1,000,000 gave the following results, which show a fairly uniform distribution of the copper throughout the water during this period: —

Twenty-four Hours after dosing.

Tank.	$CuSO_4.5H_2O$ found (Parts per 100,000).	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —
Surface,	.08940	1,100,000
Bottom,	.12040	840,000

Nine Days after dosing.

Surface,	.07416	1,300,000
Bottom,	.07637	1,200,000

Fifteen Days after dosing.

Surface,	.08288	1,200,000
Middle,	.07852	1,300,000
Bottom,	.10208	980,000

Twenty Days after dosing.

Surface,	.08084	1,200,000
Bottom,	.07381	1,400,000

Investigations at the Lawrence Experiment Station upon the Precipitation of Copper Sulphate when present in Water, its Absorption by Organic Matter, etc.

At Lawrence various experiments have been made upon the precipitation of copper sulphate in waters, and upon the absorption or combination of copper sulphate with organic and mineral matter, together with experiments upon the passing of the copper into solution again on ac-

count of the disintegration or decay of the organic matter with which it is temporarily combined or to which it adheres. This work was as follows: —

Experiment No. 213.[1]

On March 2, 1905, two wooden tanks, slightly more than 28 inches in diameter and 6 feet in depth, were filled with Lawrence water. These tanks have a capacity of 26.3 cubic feet. Tank No. 1 was half filled with water, the copper sulphate added, and then the tank was filled, the water being constantly stirred. In the second tank the copper sulphate was added to the surface water after the tank was filled. The amount placed in each tank was, as nearly as could be determined, 1 part of copper sulphate to 1,000,000 parts of water, and the water used was free from copper, as shown by analysis. A sample taken after filling Tank No. 1 showed, upon analysis, 1 part copper sulphate in 1,100,000. Twenty-four hours after filling, samples were taken from the surface, middle and bottom of Tank No. 2, and, upon analysis, gave the following results: —

Twenty-four Hours after filling.

Tank.		1 Part $CuSO_4.5H_2O$ in (Parts of Water) —
No. 2	Surface,	1,200,000
	Middle,	1,000,000
	Bottom,	940,000
Seven Days after filling.		
No. 1	Surface,	1,300,000
	Middle,	1,300,000
	6 inches from bottom,	1,500,000
No. 2	Surface,	1,200,000
	Middle,	1,100,000
	6 inches from bottom,	1,300,000
Fifty-four Days after filling.		
No. 1	Surface,	2,700,000
	Bottom,	2,700,000
No. 2	Surface,	2,600,000
	Bottom,	2,700,000

On May 3, examination of the residue from the bottom of each tank showed 1 part copper sulphate in 850,000 parts of water in Tank No. 1, and 1 part copper sulphate in 530,000 parts of water in Tank No. 2. At this time thin layers of wood were planed from the interior

[1] Experiments are given in this report with the numbers by which they are designated in the experiment station records.

of each tank, and it was found that the wood itself had absorbed enough copper to account for the decrease.

Experiment No. 219.

On June 2 a second experiment of like nature was started, the same tanks being used. Tank No. 1 was filled with canal water (Merrimack River water), to which copper sulphate in solution was added to the extent of 1 part in 1,000,000. In the bottom of this tank excelsior was placed, the amount used weighing approximately 270 grams. Tank No. 2 was filled with city water, to which 5 per cent. of sewage was added, and copper sulphate in solution was applied to the surface of the water in amount equivalent to 1 part in 1,000,000, reckoned on the total contents of the tank. In the bottom of this tank a considerable layer of river silt, weighing about 12 pounds 8 ounces, was placed. This silt made a layer about 1.7 inches in depth. Samples of water used were taken from each tank and examined for copper before introducing copper sulphate, and a very small amount was found, — not enough to interfere with the experiments. Sixteen hours, seven days, twenty-nine days and sixty-two days after the beginning of the experiments, average samples of the water in each tank were taken for analysis. The results follow: —

Tank.		1 Part $CuSO_4 \cdot 5H_2O$ in (Parts of Water) —
No. 1,		1,100,000
No. 2,		1,200,000
May 17, after standing Seven Days.		
No. 1	Surface,	1,500,000
	6 inches above bottom,	1,000,000
No. 2	Surface,	1,200,000
	6 inches above bottom,	1,100,000
June 8, after standing Twenty-nine Days.		
No. 1	Surface,	1,300,000
	6 inches above bottom,	1,400,000
No. 2	Surface,	1,100,000
	6 inches above bottom,	1,400,000
July 11, after standing Sixty-two Days.		
No. 1	Surface,	2,600,000
	6 inches above bottom,	2,100,000
No. 2	Surface,	2,900,000
	6 inches above bottom,	2,200,000

At this time samples of the excelsior in the bottom of Tank No. 1, average samples of the river silt in the bottom of Tank No. 2, and thin layers of wood from measured areas on the sides of each tank, were taken, and the copper present determined. The results showed the absorption of enough to account for the decrease of copper in the water of these tanks during the experiments. On August 25, after standing one hundred and seven days, so much of the copper sulphate had been taken up by the tanks, excelsior and silt, that in Tank No. 1 there was only 1 part of sulphate in 16,000,000 of water, and in Tank No. 2, but 1 part in 25,000,000.

Experiment No. 221.

On May 17, 1905, a large tank at the station, 17.4 feet in diameter, was filled with canal water to an average depth of 41 inches. This tank had cement sides and bottom, and the latter was covered with mud to a depth of about 3 inches. Filling with water to the depth mentioned, the volume of water introduced was about 5,800 gallons; and to this water 192 grams of copper sulphate, equivalent to 1 part of the sulphate in 114,600, were added, the sulphate being first dissolved in water. One hour afterwards an average sample of the water was taken for analysis, which showed 1 part copper sulphate in 141,000. On May 25, eight days after the experiment was begun, a second average sample of water was taken, the depth of the water in the tank on this date being 38.75 inches. On examination this water proved to contain 1 part copper sulphate in 168,000; on June 3, after seventeen days' sedimentation, 1 part copper sulphate in 205,000 was found; and on June 7, after twenty-one days' sedimentation, 1 part in 268,000. This last result showed that practically 58 per cent. of the copper sulphate applied to the water had either been precipitated and had collected on the bottom of the tank in the mud, or had been absorbed by the sides of the tank; that is, 42 per cent. remained in solution in the water after twenty-one days. Owing, apparently, to the much greater proportion of copper sulphate used and to greater turbidity, a more rapid precipitation was obtained than in previous tank experiments. On June 8 the tank was drained, and the mud from 50 accurately measured areas, representing $\frac{1}{86}$ of the total area, was taken for examination. This sample weighed 6.55 pounds, and contained 12 parts of copper, or 47.1 parts of copper sulphate per 100,000, and, assuming it to be a good average sample of the whole, accounted for 118 grams, or 61 per cent. of the copper sulphate added. As stated above, 42 per cent. of the added copper sulphate was found in the water.

On June 9 the tank was refilled with canal water, the mud being considerably stirred during this refilling, and also stirred from time to

time afterwards. On July 11 an average sample of water was taken for examination. This yielded 1 part copper sulphate per 4,600,000; that is, this amount of copper had been again taken up by the water from that deposited upon the mud during the first portion of this experiment.

On August 25 the water and mud in the tank having been stirred once or twice in the interval, the water yielded 1 part copper sulphate per 7,700,000, showing that a portion of that taken up by the water at the time of refilling the tank had again settled; and on October 4 a sample yielded 1 part copper sulphate in 8,500,000.

Experiment No. 220.

On May 16, 1905, five glass aquaria, holding about 15 liters each, were filled with water containing copper sulphate in the proportion of 1 part in 133,000. In these aquaria the following substances were placed: in No. 1, a known weight of dried leaves; in No. 2, a known weight of river silt; in No. 3, a known weight of sand from the surface of a sewage filter; in No. 4, a known weight of garden loam; and in No. 5, a known weight of peat.

At the end of one month all the water in each glass vessel was removed and examined for copper. Throughout the period of the experiment the sand, leaves, etc., in the various aquaria were stirred from time to time, in order to bring them thoroughly into contact with the water. The results of the analyses of water at the end of the first month showed that the dried leaves in Aquarium No. 1 had absorbed 90 per cent. of the copper; the river silt in No. 2, 87 per cent.; the sand from the sewage filter in No. 3, 93 per cent.; the garden loam in No. 4, 97 per cent.; and the peat in No. 5, 99 per cent. The aquaria were refilled with water free from copper sulphate, allowed to stand for a week, and the material in each stirred from time to time. At the end of the week the water was again removed from each aquarium and examined for copper. These analyses showed that the water from Aquarium No. 1 contained copper sulphate in the proportion of 1 part in 15,000,000; that of No. 2, in the proportion of 1 part in 4,400,000; that of No. 3, in the proportion of 1 part in 4,400,000; that of No. 4, 1 part in 28,000,000; and that of No. 5, 1 part in 4,800,000. That is to say, in each case the fresh water had taken from the dried leaves, sand, etc., in each aquarium but a very small percentage of the copper absorbed by these materials during the first month of the experiment, the amount taken varying from less than .5 to about 3 per cent. At the end of this second period, samples of the leaves, river silt, sand, loam and peat were analyzed, and shown to contain all the copper not found in the water

examined at the end of the two periods. Following this, water free from copper sulphate was passed for a considerable period through each material, and, upon analysis, showed the following amounts of copper sulphate: —

Water passed through —	1 Part $CuSO_4.5H_2O$ in (Parts of Water) —
Leaves,	12,000,000
River silt,	8,500,000
Sand,	12,000,000
Garden loam,	7,600,000
Peat,	17,000,000

That is to say, each of these materials gradually gave up copper to the water passing through. On October 4 and December 5 further samples of water passing through gave the following results, showing that the copper was still being slowly given up: —

Water passed through —	1 Part $CuSO_4.5H_2O$ in (Parts of Water) —	
	October 4.	December 5.
Leaves,	11,000,000	19,000,000
River silt,	7,700,000	5,500,000
Sand,	9,500,000	4,900,000
Garden loam,	7,700,000	4,800,000
Peat,	15,000,000	10,000,000

The following table shows the weight of the materials used in the aquaria and the per cent. of organic matter, as determined by the loss on ignition of each material: —

Aquarium Number.	Material.	Number of Grams of Dry Material used.	Per Cent. Loss on Ignition.
1,	Leaves,	107	85.40
2,	River silt,	782	.61
3,	Sand,	688	2.69
4,	Garden loam,	635	9.26
5,	Peat,	424	90.50

Experiment No. 252.

This experiment was made in order to study further the passing back into solution of copper or copper sulphate from decaying organic matter after it has first been taken from solution by the organic matter. Instead, however, of a more or less stable organic matter used in previous experiments, and such as is found in most reservoirs, putrefying sewage sludge was used. A solution of copper sulphate, containing 1 part copper sulphate in 720,000 was made up, and the sludge was introduced, stirred and kept in agitation a considerable portion of the time for several hours. The sludge, taking with it a large part of the copper in the solution, was then filtered off, and placed in glass tubes 1½ inches in diameter, over the lower end of which parchment paper was tied, and the tubes were then inserted into bottles of water and kept in a warm place. Treated in this way the sludge rapidly decomposed, as shown by the evolution of gas, odors, etc.; and at the end of one week and again at the end of three weeks all the water in each bottle was analyzed. The copper found is shown in the following table, indicating that it was passing into the water quite rapidly, owing to the decomposition of the unstable organic matter.

Bottle Number.	1 Part $CuSO_4.5H_2O$ in (Parts of Water) —	
	End of One Week.	End of Three Weeks.
1, ...	2,500,000	2,900,000
2, ...	930,000	9,300,000

Copper, Copper Sulphate, etc., as a Bactericide.

At the experiment station long-continued investigations have been made to learn the truth in regard to the bactericidal effect of copper, copper sulphate, and one or two other metals and their salts. In this work single experiments in many instances have covered periods of several months; and, besides the bacterial work involved, a number of determinations of copper, etc., have been made in connection with the work in regard to the metal itself as a bactericide.

The experiments are divided into two classes: (1) experiments in which waters were treated with definite amounts of copper as copper sulphate; and (2) experiments in which the water was placed in contact with metallic copper and allowed to absorb an unknown amount thereof. Each of these two lines of investigations can be sub-divided

as follows: (*a*) effect on the total numbers of bacteria in water; (*b*) effect on the numbers of B. coli naturally present in polluted waters; (*c*) effect on the numbers of B. coli added to water in the form of laboratory cultures; (*d*) effect on the numbers of B. typhosus added to water in the form of laboratory cultures.

Experiments with ferrous sulphate and aluminium sulphate, salts frequently used in water purification, have been made, and the efficiency of iron, zinc, tin, lead, etc., has been compared with that of copper as a bactericide.

In experiments in which the water was treated with metallic salts it was first drawn in bulk, carefully mixed and sampled, and then divided into portions of uniform size, one of which, the control, was carried through untreated, the others being treated with varying amounts of copper sulphate. etc. The containers were in all cases of glass, and the experiments were carried on in the dark, at room temperature. Frequent bacterial analyses were made of the contents of the various bottles in each experiment, and in a few experiments a number of analyses were made during the first twenty-four hours. The volume of water used varied considerably; in some experiments only 100 cubic centimeters of water, in others 1,000 cubic centimeters, and in a few experiments 3,000 cubic centimeters were treated.

In each of the experiments in which the waters were exposed to metallic copper about 15 liters were used. In experiments in which a number of metals were under comparison the volume of water used was about 1,000 cubic centimeters. In the metal experiments the containers in some cases were of copper, with the control in enamelled ware or in glazed stoneware; in others the waters were placed in glass, and the metals inserted as thin sheets. Determinations of the numbers of bacteria and of B. coli in the raw waters were made by the usual Lawrence methods. Dealing with sterile waters, seeded with laboratory cultures of B. coli and B. typhosus, counts were made with agar plates incubated eighteen hours at body temperature. Tests with volumes larger than 1 cubic centimeter were made by mixing the broth with water and incubating at body temperature, and, in case a growth was obtained, identifying the test organisms by the usual cultural tests. In the following tables the sign "+" indicates there was no growth on plates, but that the organism was proved to be present by qualitative tests. A number of different methods of expressing the copper content of waters have been used in recent publications, the most common being the expression of the ratio of copper sulphate to water by weight. This method has been followed in the previous portion of this report, and is satisfactory in speaking of the treatment of large bodies of water for the

destruction of microscopical organisms by copper sulphate. In this chapter, however, it is more reasonable and convenient to express the results in parts of copper per 100,000 parts of water, especially when copper sulphate treatment is compared with metallic copper treatment; and this method of expression has been used throughout the following tables, although in some cases both methods of expression have been used in the text. The following equivalent weights of the metals and the metallic salts are given for comparison: —

Copper sulphate ($CuSO_4.5H_2O$) : Copper (Cu) $= 1:0.253$.

Ferrous sulphate ($FeSO_4.7H_2O$) : Iron (Fe) $= 1:0.201$.

Aluminium sulphate ($Al_2(SO_4)_5$) : Aluminium (Al) $= 1:0.158$.

Expressing the parts of copper, as given in the following tables, in equivalent amounts of copper sulphate, the following table is of service: —

Parts Copper per 100,000.		1 Part $CuSO_4.5H_2O$ in (Parts of Water) —	Parts Copper per 100,000.		1 Part $CuSO_4.5H_2O$ in (Parts of Water) —
253	=	100	0.0253	=	1,000,000
25.3	=	1,000	0.00253	=	10,000,000
2.53	=	10,000	0.000253	=	100,000,000
0.253	=	100,000			

In the following summary of experiments the various bottles, or containers, in each experiment are designated by the amount of copper added in parts per 100,000.

Experiment No. 159.

Merrimack River water. Copper range, .000253 to 253. Duration, ten days. The bacteria in .000253 and .00253 acted like the control. In .0253 and .253 the bacteria increased. In 2.53 and 25.3 all but a few of the bacteria were killed, these few remaining throughout the experiment. In 253 the bacteria were all destroyed. The bacterial results are shown in Table No. 1.

Experiment No. 163.

Merrimack River water, containing 1 per cent. of sewage. Range, .000253 to 253. Duration twenty days. The numbers of bacteria in the control were higher in twenty-four hours than they were at the

start, but decreased slowly during the experiment. The bacteria in .000253, .00253 and 0.253 were nearly all destroyed in twenty-four hours, but the few remaining increased largely in the course of three or four days. In .0253 the bacteria increased immediately, and then decreased slowly. In 2.53 and 25.3 nearly all of the bacteria were destroyed, but the few remaining were alive during twenty days. In 253 all of the bacteria were destroyed in two days. The bacterial results are shown in Table No. 2.

Experiment No. 210.

Merrimack River water, containing .1 per cent. of sewage by volume. Duration, one hundred and thirty-one days. Range, .000253 to 2.53. The bacteria in the control increased at first and then decreased slowly until the one hundred and sixteenth day, when a slight secondary increase was noted; .000253, .00253 and .0253 all increased largely during the first two or three days, and then decreased slowly. In .000253 and .00253, a secondary increase in the numbers of bacteria was noted on the eighty-eighth and ninety-fifth days, respectively, but no secondary increase of any importance occurred in .0253. In .253, the numbers were considerably reduced in twenty-four hours, but immediately increased to large numbers on the fifth day and then slowly declined. In 2.53, more than 90 per cent. of the bacteria were destroyed in twenty-four hours, and these numbers remained small and gradually decreased throughout the experiment, with the exception of one small secondary increase, which occurred from the fifteenth to the eighteenth day.

The number of B. coli in all of the bottles fluctuated considerably, but decreased gradually throughout the experiment; they were found in small numbers up to the ninety-fifth and one hundred and third day, with the exception of .253, from which they disappeared on the sixty-seventh day. Tests in volumes larger than 1 cubic centimeter were not made. The bacterial results are shown in Table No. 3, and the B. coli results in Table No. 10.

Experiment No. 193.

Tap water, containing 3 per cent. of sewage. Duration, one hundred and eighty-seven days. Range, .0000253 to 25.3. The bacteria in the control increased until the second day and then slowly decreased during ninety-six days, when a large secondary increase occurred, lasting through the one hundred and forty-fifth day, when a decrease again occurred. In .0000253, .000253 and .00253, the bacteria all followed much the same laws as the control, both as to increase, gradual decrease and a secondary increase after about one hundred days. In .0253, a primary increase and decrease of bacteria followed the normal curve, only a slight secondary in-

crease being noted. In .253, more than 99 per cent. of the bacteria disappeared in twenty-four hours, but they increased largely during the succeeding week and then slowly decreased throughout the experiment. In 2.53, the bacteria decreased more than 99 per cent. in twenty-four hours, and the number remaining was practically constant until the seventh day, when an increase occurred which lasted about two weeks, the numbers fluctuating and gradually falling off until the water became sterile on the eighty-ninth day. In 25.3, practically all of the bacteria were destroyed in twenty-four hours, small numbers being occasionally found until the eighty-second day, when the water became sterile. The bacterial results are shown in Table No. 4.

Experiment No. 176.

Water from a stagnant reservoir.[1] Duration, three days. Range, .000253 to .0253. The bacteria in the control and in .000253 decreased, while in .00253 and .0253 they increased, the greatest increase being noted in the bottle containing the largest amount of copper. The bacterial results are shown in Table No. 5.

Experiment No. 177.

Water from a stagnant reservoir. Duration, twelve days. Range, .00253 to .0253. The bacteria in all of the bottles followed the same course, increasing rapidly during the first two or three days and then decreasing slowly. The bacterial results are shown in Table No. 6.

Experiment No. 179.

Water from a stagnant reservoir. Duration, eight days. Range, .00253 to 2.53. The bacteria in the control fluctuated somewhat, but decreased throughout the experiment. In .00253, the numbers decreased during the first six days and then showed an increase on the eighth day. In .0253, the numbers decreased during the first two days and then increased largely, the same being true with 0.253. In 2.53, more than 90 per cent. of the bacteria were destroyed in twenty-four hours and those remaining continued to decrease to the sixth day, a large secondary increase being noted on the eighth day. The bacterial results are shown in Table No. 7.

Experiment No. 187.

Water from a stagnant reservoir. Duration, twelve days. Range, .00253 to 2.53. The bacteria in the control increased slowly through-

[1] A large tank at the station, 17 feet in diameter, in which water had been standing for many weeks.

out the experiment. In .00253, they increased during the first three days and then fluctuated, but decreased throughout the remainder of the experiment. In .0253, more than 90 per cent. of the bacteria were killed in twenty-four hours, but then increased rapidly throughout the experiment. In 0.253, the bacteria decreased during the first two days and then increased largely until the fifth day, a decrease following throughout the experiment. In 2.53, more than 95 per cent. of the bacteria were killed in twenty-four hours, the few survivors remaining practically constant with the usual slight fluctuations. The bacterial results are shown in Table No. 8.

Experiment No. 185.

Driven well water. Duration, one hundred and thirty-three days. Range, .000253 to .253. There were but 31 bacteria per cubic centimeter at the start. In all the samples a large increase was noted in twenty-four to forty-eight hours. The numbers in the control, .000253, and .00253, remained practically constant after forty-eight hours for forty-five days, after which they began to decrease slowly. In 0.0253, a considerable decrease occurred about the eighty-fourth day, the numbers remaining low after that time. In .253, the numbers were below 100 on the thirty-first day, and continued low, with the exception of one count, throughout the experiment. The bacterial results are shown in Table No. 9.

Experiment No. 164.

Forty-eight-hour broth culture of B. coli, diluted 1:10,000 with sterile tap water. Duration, six days. Range, .000253 to 253. The B. coli in the control decreased during the first two days and then began to increase. In .000253, about 50 per cent. were killed in twenty-four hours, and the remainder decreased rapidly until the water became sterile on the sixth day. In .00253 and .0253, all but a few of the germs were killed in twenty-four hours, and the water became sterile on the third and second days, respectively. In .253 to 253, inclusive, all of the test organisms were killed in twenty-four hours. The detailed results are shown in Table No. 11.

Experiment No. 161.

Forty-eight-hour broth culture of B. typhosus, diluted 1:10,000 with sterile tap water. Duration, three days. Range, .000253 to 253, inclusive. The test organisms disappeared from the control in twenty-four hours. In .000253, a large increase was noted in twenty-four hours. In .00253 about 90 per cent. of the organisms were destroyed in twenty-four hours, and the water became sterile on the third day. In .0253 to 253, inclusive, like the control, the water was sterile after twenty-four hours. The detailed results are shown in Table No. 12.

Experiment No. 191.

Twenty-four-hour broth culture of B. typhosus, diluted 1:10,000 with sterile tap water. Duration, twenty-eight days. Range, .000253 to .253. The test organisms in the control diminished gradually from 115,000 at the start to only 4 organisms on the third day, and then increased rapidly to over 400,000 on the sixth day, after which they decreased slowly throughout the experiment. The same result was noted in .000253, the bacteria declining to 5 in twenty-four hours, after which they increased to more than 54,000 on the seventh day, and then gradually decreased. In .00253, the organisms were destroyed rapidly, about 90 per cent. being killed during the first hour, and in twenty-four hours 10 cubic centimeters of the water were required to demonstrate the presence of the organism. On the second day, however, the organisms had increased, and small numbers were present until the twelfth day. From the fourteenth to the twenty-eighth day, B. typhosus was not found in 1-cubic-centimeter samples, but was demonstrable in 10 cubic centimeters. In .0253, more than 90 per cent. of the organisms were destroyed in thirty minutes, and nearly all disappeared in six hours. From the second to the fifth days the organism was demonstrable in 10 cubic centimeters, and on the sixth day in 100 cubic centimeters. The water became sterile on the seventh day. In .253, more than 95 per cent. of the organisms disappeared in the first thirty minutes, and the decrease was so rapid that after six hours it required 10 cubic centimeters of the water to obtain a positive test. The organism was found continuously in 10 cubic centimeters through the fifth day, and was demonstrable in 100 cubic centimeters on the sixth day. The water became sterile on the seventh day. The detailed results are shown in Table No. 13.

Experiment No. 194.

Twenty-four-hour broth culture of B. typhosus, diluted 1:500 with sterile tap water. Duration, 10 days. Range, .0000253 to 2.53. The infected water in the various bottles was allowed to stand four days before adding copper; in order that the organisms might become in a measure accustomed to their new environment before being subjected to the action of the copper sulphate. The numbers of B. typhosus during these four days increased in four of the bottles and decreased more or less in the other four. In the two bottles which were retained as controls, the organisms continued to increase during the ten days they were under observation, the same being true of the waters containing copper .0000253, .000253 and .00253. In the water containing copper .0253, the numbers remained practically constant during the ten days. In .253 and 2.53, the numbers fell off rapidly, being practically all

eliminated in twenty-four hours, the waters becoming sterile in forty-eight hours. Tests were not made in volumes larger than 1 cubic centimeter in this experiment. The detailed results are shown in Table No. 14.

TABLE NO. 1.— *Experiment No. 159. Merrimack River Water.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water) — 100,000,000. / Copper (Parts per 100,000) — 0.000253.	10,000,000. / 0.00253.	1,000,000. / 0.0253.	100,000. / 0.253.	10,000. / 2.53.	1,000. / 25.3.	100. / 253.
Start,	3,800	-	-	-	-	-	-	-
1 day,	-	10,000	22,400	340,800	30	9	3	0
2 days,	-	4,800	16,000	357,000	88,600	9	0	0
3 days,	-	2,500	11,800	300,000	103,000	10	6	1
4 days,	-	3,600	9,700	315,000	157,500	12	2	0
6 days,	-	1,100	2,400	10,300	79,200	27	0	0
8 days,	-	1,800	3,500	7,500	97,500	11	2	0
10 days,	-	410	870	4,700	118,800	9	8	0

TABLE NO. 2.— *Experiment No. 163. Merrimack River Water, to which was added 1 Per Cent. of Lawrence Sewage.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water) — 100,000,000. / Copper (Parts per 100,000) — 0.000253.	10,000,000. / 0.00253.	1,000,000. / 0.0253.	100,000. / 0.253.	10,000. / 2.53.	1,000. / 25.3.	100. / 253.
Start,	46,000	-	-	-	-	-	-	-
1 day,	69,000	37	8	333,000	80	20	8	3
2 days,	41,500	19	13	404,500	4,200	6	9	0
3 days,	12,500	65	34	610,000	3,900	26	23	0
4 days,	13,700	447,300	125,700	138,500	4,400	28	35	1
6 days,	7,400	590,000	55	83,100	130,800	14	3	0
8 days,	8,000	71,000	18,500	220,000	85,200	20	16	0
10 days,	4,200	37,350	21	56,200	55,500	15	8	0
13 days,	4,400	25,600	23	33,000	15,600	14	12	0
20 days,	1,400	100	15	1,700	3,300	7	8	1

TABLE NO. 3.— *Experiment No. 210. Merrimack River Water, to which was added .1 Per Cent. of Lawrence Sewage.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water)—				
		100,000,000.	10,000,000.	1,000,000.	100,000.	10,000.
		Copper (Parts per 100,000)—				
		0.000253.	0.00253.	0.0253.	0.253.	2.53.
Start,	17,000	-	-	-	-	-
1 day,	72,500	18,500	115,000	132,000	800	150
2 days,	64,800	68,400	87,800	87,800	7,000	18
4 days,	35,000	5,500	24,300	175,000	372,800	65
5 days,	10,700	12,300	32,600	223,200	458,900	65
6 days,	17,500	56,500	57,500	162,000	581,400	100
7 days,	12,000	15,200	50,500	90,000	151,200	100
8 days,	2,200	4,800	7,300	19,500	75,600	50
11 days,	11,000	13,300	7,300	35,500	266,300	24
13 days,	8,900	4,700	4,600	14,000	532,500	25
15 days,	8,000	7,400	3,000	7,500	450,000	2,600
18 days,	6,200	5,800	5,100	30,000	770,000	2,400
21 days,	3,300	2,400	2,650	9,100	320,000	550
25 days,	600	800	900	5,500	18,400	33
32 days,	390	450	1,600	4,500	194,400	120
39 days,	190	135	180	1,700	210,000	30
46 days,	110	210	205	830	11,400	475
53 days,	95	475	250	700	10,500	240
60 days,	65	90	65	300	8,850	75
67 days,	75	90	160	140	4,500	9
74 days,	170	85	210	100	1,425	4
81 days,	21	275	275	24	480	4
88 days,	140	1,100	725	190	175	35
95 days,	120	2,700	1,100	530	500	9
103 days,	38	75	210	55	230	1
109 days,	55	160	350	300	275	5
116 days,	1,100	120	5,000	150	325	7
123 days,	1,100	750	2,350	90	180	27
131 days,	500	400	1,100	400	550	1

TABLE No. 4.—*Experiment No. 193. Lawrence City Water, to which was added 3 Per Cent. by Volume of Lawrence Sewage.*

[Bacteria per cubic centimeter.]

ELAPSED TIME.	Control.	1 PART COPPER SULPHATE IN (PARTS OF WATER)—						
		1,000,000,000.	100,000,000.	10,000,000.	1,000,000.	100,000.	10,000.	1,000.
		COPPER (PARTS PER 100,000)—						
		0.0000253.	0.000253.	0.00253.	0.0253.	0.253.	2.53.	25.3.
Start, . . .	96,400	–	–	–	–	–	–	–
½ hour, . .	93,000	76,400	92,600	44,400	51,000	4,800	24,200	4,600
1 hour, . .	76,000	123,000	92,600	73,200	50,000	2,800	7,700	3,100
2 hours, . .	106,500	84,200	110,800	60,200	31,900	1,420	6,200	530
4 hours, . .	92,300	84,000	132,100	73,000	13,200	350	730	130
6 hours, . .	84,400	95,000	140,600	84,400	11,000	210	300	80
8 hours, . .	86,400	75,600	114,500	72,500	8,800	150	175	70
24 hours, . .	1,000,000	1,120,000	1,150,000	1,150,000	1,500,000	20	2	1
2 days, . .	1,100,000	1,400,000	795,200	284,000	1,930,000	220,000	2	0
3 days, . .	108,000	370,000	6,400	324,000	1,420,000	990,000	2	3
5 days, . .	13,400	44,700	32,200	22,600	1,020,000	1,500,000	5	0
7 days, . .	7,500	11,200	16,500	270,000	475,200	276,500	43	5
13 days, . .	2,300	4,300	1,000	4,600	4,100	2,360,000	2,400	4
16 days, . .	2,400	5,500	5,800	5,400	19,500	73,400	6,600	5
21 days, . .	800	4,600	4,800	4,000	11,500	33,800	13,200	1
26 days, . .	3,100	4,800	7,200	6,200	12,800	47,000	32,000	5
33 days, . .	800	6,500	2,000	3,300	8,500	26,500	15	6
40 days, . .	500	6,000	1,250	1,700	5,350	15,500	6	0
47 days, . .	3,400	7,700	4,600	2,500	7,600	11,800	1,080	4
55 days, . .	480	3,700	2,600	1,200	2,400	162,000	6,800	3
61 days, . .	230	185	200	370	440	210,000	4	7
68 days, . .	190	650	390	110	850	–	4	4
75 days, . .	225	325	510	160	1,850	150,000	3	3
82 days, . .	300	310	550	350	600	88,600	2	0
89 days, . .	750	4,700	500	225	275	–	0	0
96 days, . .	300	2,200	250	1,150	510	6,500	0	0
103 days, . .	29,100	20,000	740	1,700	660	41,000	0	0
110 days, . .	75,000	3,200	1,500	650	270	37,500	0	0
117 days, . .	60,000	3,800	475	3,400	300	40,000	0	0
124 days, . .	28,600	10,400	590	1,200	240	25,000	0	0
131 days, . .	22,600	1,300	880	600	300	7,900	0	0
145 days, . .	594,000	5,600	660	725	650	33,500	0	0
160 days, . .	650	1,800	1,100	650	57	8,000	0	0
173 days, . .	6,600	30,900	3,500	5,300	2,000	47,200	0	0
187 days, . .	1,600	2,750	700	300	70	5,900	0	0

TABLE No. 5. — *Experiment No. 176. Water from Stagnant Reservoir.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water) — 100,000,000. Copper (Parts per 100,000) — 0.000253.	10,000,000. 0.00253.	1,000,000. 0.0253.
Start,	120	-	-	-
1 day,	110	210	400	700
2 days,	34	55	1,900	19,000
3 days,	13	31	1,800	12,400

TABLE No. 6. — *Experiment No. 177. Water from Stagnant Reservoir.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water) — 10,000,000. Copper (Parts per 100,000) — 0.00253.	5,000,000. 0.00506.	1,000,000. 0.0253.
Start,	3,900	-	-	-
1 day,	29,400	22,000	24,500	24,500
2 days,	16,900	22,900	90,200	144,000
3 days,	10,100	16,400	40,000	165,600
5 days,	6,800	4,100	21,000	10,500
7 days,	5,000	4,700	4,000	6,900
9 days,	4,200	10,500	32,500	90,000
12 days,	270	420	3,600	2,500

TABLE No. 7. — *Experiment No. 179. Water from Stagnant Reservoir.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water) — 10,000,000. Copper (Parts per 100,000) — 0.00253.	1,000,000. 0.0253.	100,000. 0.253.	10,000. 2.53.
Start,	300	-	-	-	-
1 day,	35	255	100	135	21
2 days,	45	400	36	28	9
4 days,	700	300	113,600	97,200	1
6 days,	80	75	10,600	1,800	2
8 days,	245	4,100	52,000	1,900	2,300

TABLE NO. 8. — *Experiment No. 187. Water from Stagnant Reservoir.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water) — 10,000,000.	1,000,000.	100,000.	10,000.
		Copper (Parts per 100,000) — 0.00253.	0.0253.	0.253.	2.53.
Start,	265	-	-	-	-
1 day,	230	210	16	95	9
2 days,	1,500	2,500	1,300	65	0
3 days,	425	11,000	10,400	23,200	2
4 days,	1,260	720	38,800	442,800	0
5 days,	1,118	7,200	48,400	630,000	-
7 days,	4,500	700	1,900	241,900	3
9 days,	8,900	865	51,000	75,600	5
12 days,	15,500	3,200	24,000	240,000	8

TABLE NO. 9. — *Experiment No. 185. Driven Well Water.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water) — 100,000,000.	10,000,000.	1,000,000.	100,000.
		Copper (Parts per 100,000) — 0.000253.	0.00253.	0.0253.	0.253.
Start,	31	-	-	-	-
1 day,	15,700	6,700	6,300	3,700	300
2 days,	3,240	275	19,500	27,000	53,500
3 days,	1,050	440	17,000	30,000	10,300
4 days,	1,300	315	3,500	66,000	33,600
5 days,	11,800	14,500	4,700	181,100	55,000
7 days,	14,000	675	13,500	97,200	21,000
8 days,	920	9,500	20,000	66,000	41,600
10 days,	600	440	13,800	9,100	1,400
12 days,	500	5,600	16,600	46,000	1,200
15 days,	900	13,500	11,000	80,600	500
17 days,	7,500	3,600	17,500	33,000	100
19 days,	1,500	7,200	13,500	10,800	3,100
21 days,	5,200	4,700	10,600	20,600	260
23 days,	6,400	1,600	4,700	11,600	125
25 days,	8,000	9,600	13,200	17,600	230
28 days,	430	2,900	5,600	14,800	140
31 days,	4,100	6,500	5,900	13,600	15
35 days,	4,300	3,100	3,000	14,800	38
38 days,	2,500	4,600	4,300	12,000	95
42 days,	335	85	3,600	11,000	65
45 days,	1,100	1,800	2,400	9,200	4
49 days,	290	100	600	5,100	1
57 days,	200	40	1,600	4,000	5
65 days,	3,200	75	2,000	800	9
70 days,	2,400	800	700	250	18
77 days,	1,600	12	55	1,700	340
84 days,	900	65	550	10	0
91 days,	1,000	475	2,900	165	10
99 days,	200	200	350	0	6
105 days,	95	25	625	33	8
112 days,	35	24	110	2	2
119 days,	140	37	375	28	10
126 days,	133	15	250	8	7
133 days,	143	330	265	24	10

TABLE NO. 10.—*Experiment No. 210. Merrimack River Water, to which was added .1 Per Cent. of Lawrence Sewage.*

[B. coli per cubic centimeter.]

ELAPSED TIME.	Control.	1 PART COPPER SULPHATE IN (PARTS OF WATER)—				
		100,000,000.	10,000.000.	1,000,000.	100,000.	10,000.
		COPPER (PARTS PER 100,000)—				
		0.000253.	0.00253.	0.0253.	0.253.	2.53.
Start,	70	–	–	–	–	–
1 day,	31	45	32	28	17	10
2 days,	2	3	2	0	0	0
4 days,	20	7	10	101	13	23
5 days,	15	2	17	6	0	0
6 days,	43	56	48	47	34	42
7 days,	12	11	0	9	2	0
8 days,	7	7	8	0	0	50
11 days,	12	30	5	3	18	0
13 days,	+	3	0	2	4	3
15 days,	10	+	0	30	7	6
18 days,	0	17	27	41	10	16
21 days,	0	10	11	5	13	13
25 days,	8	18	25	26	8	11
32 days,	0	12	16	3	16	6
39 days,	3	0	10	4	0	1
46 days,	3	0	3	14	20	14
53 days,	0	1	0	5	2	1
60 days,	4	1	0	5	0	8
67 days,	0	0	7	0	5	3
74 days,	2	1	0	0	0	1
81 days,	0	0	0	0	0	0
88 days,	4	3	2	0	18	5
95 days,	1	0	0	0	0	1
103 days,	0	0	0	0	0	1

TABLE NO. 11.—*Experiment No. 164. Forty-eight-hour Broth Culture of B. Coli, diluted 1:10,000 with Sterile Tap Water.*

[B. coli per cubic centimeter.]

ELAPSED TIME.	Control.	1 PART COPPER SULPHATE IN (PARTS OF WATER)—						
		100,000,000.	10,000,000.	1,000,000.	100,000.	10,000.	1,000.	100.
		COPPER (PARTS PER 100,000)—						
		0.000253.	0.00253.	0.0253.	0.253.	2.53.	25.3.	253.
Start,	15,400	–	–	–	–	–	–	–
1 day,	2,500	800	2	1	0	0	0	0
2 days,	1,200	67	3	0	0	0	0	0
3 days,	1,600	7	0	0	0	0	0	0
4 days,	25,600	5	0	0	0	0	0	0
6 days,	580,000	0	0	0	0	0	0	0

TABLE No. 12.— *Experiment No. 161. Forty-eight-hour Broth Culture of B. Typhosus, diluted 1 : 10,000 with Sterile Tap Water.*

[B. typhosus per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water)—						
		100,000,000.	10,000,000.	1,000,000.	100,000.	10,000.	1,000.	100.
		Copper (Parts per 100,000)—						
		0.000253.	0.00253.	0.0253.	0.253.	2.53.	25.3.	253.
Start,	3,100	-	-	-	-	-	-	-
1 day,	0	23,300	48	0	0	0	0	0
2 days,	0	8,400	2	0	0	0	0	0
3 days,	0	21,000	0	0	0	0	0	0

TABLE No. 13 — *Experiment No. 191. Twenty-four-hour Broth Culture of B. Typhosus, diluted 1 : 10,000 with Sterile Tap Water.*

[B. typhosus per cubic centimeter.]

Elapsed Time.	Control.	1 Part Copper Sulphate in (Parts of Water)—			
		100,000,000.	10,000,000.	1,000,000.	100,000.
		Copper (Parts per 100,000)—			
		0.000253.	0.00253.	0.0253.	0.253.
Start,	115,500	-	-	-	-
½ hour,	71,000	234,000	14,500	6,500	520
1 hour,	100,800	90,000	195	1,000	24
2 hours,	47,000	30,000	85	65	26
4 hours,	25,000	4,800	2	18	1
6 hours,	3,000	900	+ [1]	2	+ [1]
8 hours,	2,800	770	1	+ [1]	+ [1]
24 hours,	770	5	+ [1]	1	+ [1]
2 days,	12	6,300	6,525	+ [1]	+ [1]
3 days,	4	240	-	+ [1]	+ [1]
5 days,	52,000	1,100	8	+ [1]	+ [1]
6 days,	420,000	22,000	8	+ [2]	+ [2]
7 days,	260,000	54,000	8	0 [3]	0 [3]
8 days,	230,000	47,000	5	0 [3]	0 [3]
9 days,	220,000	35,000	4	-	-
10 days,	80,000	30,000	2	-	-
12 days,	260,000	29,000	7	-	-
14 days,	118,800	42,000	+ [1]	-	-
16 days,	86,400	36,000	+ [1]	-	-
20 days,	61,200	12,300	+ [1]	-	-
22 days,	72,100	24,200	+ [1]	-	-
28 days,	237,000	16,000	+ [1]	-	-

[1] 1 c. c. = 0, 10 c. c. = +. [2] 1-10 c. c. = 0, 100 c. c. = +. [3] 1, 10 and 100 c. c. = 0.

Table No. 14.—*Experiment No. 194. Twenty-four-hour Broth Culture of B. Typhosus diluted 1 : 500 with Sterile Tap Water and allowed to stand Four Days before adding Copper Sulphate.*

[B. typhosus per cubic centimeter.]

Elapsed Time.	Before adding Copper.							
	A.	B.	C.	D.	E.	F.	G.	H.
Start,	1,280,000	1,200,000	1,200,000	1,200,000	1,200,000	1,280,000	1,280,000	1,280,000
1 day,	450,000	200,000	120,000	104,400	200,000	420,000	480,000	300,000
2 days,	1,080,000	79,200	28,500	59,000	93,600	1,090,000	950,000	940,000
3 days,	2,200,000	210,000	75,600	75,600	165,600	1,850,000	2,430,000	2,200,000
4 days,	3,000,000	313,200	118,800	85,200	777,600	2,500,000	2,430,000	73,000

Table No. 14.—*Experiment No. 194*—Concluded.

Elapsed Time.	Control.	Duplicate Control.	Copper (Parts per 100,000)—					
			0.0000253.	0.000253.	0.00253.	0.0253.	0.253.	2.53.
30 minutes,	-	-	149,100	70,000	399,600	2,099,500	1,887,600	34,000
1 hour,	-	-	183,600	239,000	529,100	1,120,000	1,358,500	27,500
2 hours,	-	-	159,800	72,000	626,400	1,657,500	640,000	2,225
4 hours,	-	-	175,000	149,000	748,400	4,406,400	323,800	142
6 hours,	-	-	205,200	109,400	1,101,600	2,814,000	48,800	15
24 hours,	3,400,000	902,900	604,800	576,000	3,700,000	4,200,000	4	1
2 days,	2,750,000	2,000,000	1,040,000	1,980,000	2,520,000	2,750,000	0	0
3 days,	-	3,000,000	1,120,000	1,200,000	2,200,000	2,450,000	0	0
4 days,	265,000	4,400,000	330,000	14,400,000	4,500,000	3,000,000	0	0
8 days,	2,200,000	4,600,000	10,300,000	9,360,000	3,100,000	2,060,000	-	-
10 days,	1,300,000	2,230,000	-	250,000	1,650,000	1,300,000	-	-

Experiments with Metallic Copper.

Experiment No. 175.

Eighteen and five-tenths liters of Merrimack River water in copper dish. Control in a stone crock. Exposed copper area, 3,200 square centimeters. Duration, twenty days. The bacteria in the control increased. The bacteria in the copper dish, with the exception of one slight increase, fell off gradually.

The B. coli in the control were found in 1 cubic centimeter on the eighth day and in 100 cubic centimeters on the fifteenth day. In the cop-

per dish the B. coli disappeared from 100 cubic centimeters on the second day. The bacterial results are shown in Table No. 15, and the B. coli results in Table No. 18.

Experiment No. 178.

Eighteen and five-tenths liters of tap water, containing 10 per cent. by volume of sewage, in a copper dish. Control in a stone crock. Exposed copper area, 3,200 square centimeters. Duration, seventy-six days. Copper absorbed, 0.46 parts per 100,000. The bacteria in the control were practically constant throughout. The bacteria in the copper dish increased rapidly and then slowly decreased, until the water was practically sterile on the seventy-sixth day.

The B. coli decreased rapidly in both cultures. In the control it was found in 1 cubic centimeter on the thirteenth day, but disappeared from 100 cubic centimeters on the fifteenth day. In the copper dish it was found in small numbers on the twentieth day, five days after complete disappearance from the control. The bacterial results are shown in Table No. 15, and the B. coli results in Table No. 18.

Experiment No. 183.

Eighteen and five-tenths liters of Merrimack River water in a copper dish, with control in an enamelled dish. Exposed copper area, 2,900 square centimeters. Duration, seventy-one days. Copper absorbed, 0.39 parts per 100,000. Bacteria decreased gradually in both copper and control, the water in both becoming practically sterile at the end of the experiment.

B. coli was found in 1-cubic-centimeter samples of the control on the seventeenth day and in 100 cubic centimeters on the twenty-eighth day, and disappeared on the thirtieth day. In the copper, B. coli was found in small numbers up to the sixth day, but was not demonstrable in 100 cubic centimeters on the eighth day. The bacterial results are shown in Table No. 16, and the B. coli results in Table No. 19.

Experiment No. 200.

Seventeen and three-tenths liters of Merrimack River water in a copper dish, with control in an enamelled dish. Exposed copper surface, 2,900 square centimeters. Duration, sixty-four days. Copper absorbed, 1.0 part per 100,000 (seventy-one days). Bacteria in both control and copper dish decreased gradually, the decline in the copper dish being more rapid. The contents of the copper dish were sterile on the fifty-fifth day, when only a few bacteria remained alive in the control.

B. coli was found in the control in 1-cubic-centimeter samples as late as the twentieth day, but was not demonstrable in 100 cubic centimeters on the twenty-eighth day. In the copper dish, B. coli could not be detected in 1-cubic-centimeter samples on the fourth day, but could be detected in 100 cubic centimeters as late as the thirty-fourth day, six days after it had disappeared from the control. The bacterial results are shown in Table No. 16, and the B. coli results in Table No. 19.

Experiment No. 182.

Three glass vessels, containing respectively, 18.9 liters of Merrimack River water, effluent from a sewage filter, and driven well water. Twenty-two hundred square centimeters of copper surface were inserted into each, in the form of thin sheets. Duration, seven days. Copper absorbed by river water, 0.062; by sewage effluent, 1.822; by driven well water, 0.035 parts per 100,000. The bacteria in all samples increased. The bacterial results are shown in Table No. 17.

Experiment No. 186.

Duplicate of Experiment No. 182. Duration, fourteen days. Copper absorbed by river water, 0.084; by sewage effluent, 2.400; by well water, 0.047 parts per 100,000. The numbers of bacteria in the river water showed only small fluctuations; in the sewage effluent the bacteria decreased until the fifth day, and then increased until the thirteenth day. The bacteria in the well water increased to a maximum on the tenth day, and then slowly decreased. The bacterial results are shown in Table No. 17.

Experiment No. 184.

Forty-eight-hour broth culture of B. coli, diluted 1:10,000 with sterile tap water in a copper dish, with control in an enamelled dish; 18.5 liters of water (sterilized in dish, and standing twelve days). Copper surface, 2,900 square centimeters. Duration, six days. Copper absorbed, 0.50 parts per 100,000. B. coli in the control showed a normal increase. In the copper dish, more than 99 per cent. disappeared in twenty-four hours, but a few were alive on the sixth day. The detailed results are shown in Table No. 20.

Experiment No. 189.

Forty-eight-hour broth culture of B. coli, diluted 1:10,000 with sterile tap water in a copper dish, with control in an enamelled dish; 18.5 liters of water. Copper surface, 2,900 square centimeters. Duration, twelve days. Copper absorbed, 0.68 parts per 100,000. B. coli in control

showed a normal increase. In the copper dish the numbers remained practically constant during five days, the test organisms being found in 1-cubic-centimeter samples on the eighth day, but they could not be detected in that volume on the tenth day. The detailed results are shown in Table No. 20.

Experiment No. 199.

Forty-eight-hour broth culture of B. coli, diluted 1:10,000 with sterile tap water in a copper dish, with control in an enamelled dish; 19 liters of water. Copper surface, 3,050 square centimeters. Duration, sixty-two days. Copper absorbed, 0.54 parts per 100,000. The numbers of B. coli in the control remained practically unchanged during sixty-two days. In the copper dish more than 99 per cent. of the organisms were killed in twenty-four hours, and 10 cubic centimeters of water were required for the detection of the organisms on the second and third days. On the fourth day a secondary increase began, and on the eighth day the number of B. coli increased to 4,900. On the tenth day a decline was noted. From the thirteenth to the twenty-seventh day the organism was found in 10-cubic-centimeter samples, but could not be detected in 100 cubic centimeters on the thirty-third day. The detailed results are shown in Table No. 21.

Experiment No. 190.

Forty-eight-hour broth culture of B. typhosus, diluted 1:10,000 with sterile tap water in a copper dish, with control in an enamelled dish; 18.5 liters of water. Copper surface, 2,900 square centimeters. Duration, three days. The number of B. typhosus in the control diminished rapidly, more than 99 per cent. disappearing in three days. In the copper dish the same rapid decrease was noted, more than 99 per cent. of the organisms disappearing in six hours and practically all in eight hours. After twenty-four hours, the organism was not found in 1-cubic-centimeter samples, but was detected in 100 cubic centimeters. On the second day, it was not demonstrable in the latter volume. The detailed results are shown in Table No. 22.

Experiments with Metallic Copper.

Table No. 15. — *Merrimack River Water and City Water plus Sewage.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Experiment No. 175. Merrimack River Water.		Experiment No. 178. Tap Water, containing 10 Per Cent. of Sewage.	
	Control in Stone Crock.	Copper Dish.	Control in Stone Crock.	Copper Dish.
Start,	1,400	1,400	320,000	390,000
1 day,	9,300	1,500	1,950,000	1,440,000
2 days,	11,000	17,300	2,980,000	3,430,000
3 days,	488,500	337	470,000	2,690,000
4 days,	1,114,000	1,600	350,000	250,000
6 days,	704,900	3,100	12,000	420,000
8 days,	16,200	95	12,000	69,000
10 days,	107,000	180	1,230,000	210,000
13 days,	125,000	85	119,000	30,000
15 days,	307,000	85	73,400	26,500
17 days,	414,000	30	77,800	39,000
20 days,	1,490,000	37	300,000	39,000
22 days,	-	-	73,000	20,000
24 days,	-	-	240,000	4,000
28 days,	-	-	180,000	12,300
30 days,	-	-	230,000	5,000
32 days,	-	-	180,000	4,500
34 days,	-	-	118,800	2,800
36 days,	-	-	29,000	3,000
38 days,	-	-	168,500	2,700
41 days,	-	-	55,000	2,500
44 days,	-	-	86,400	2,400
48 days,	-	-	101,500	3,000
55 days,	-	-	174,200	1,100
62 days,	-	-	93,600	200
70 days,	-	-	172,800	100
76 days,	-	-	350,000	3

TABLE No. 16. — *Merrimack River Water.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Experiment No. 183.		Experiment No. 200.	
	Control in Enamelled Dish.	Copper Dish.	Control in Enamelled Dish.	Copper Dish.
Start,	600	1,200	11,000	10,500
½ hour,	–	–	12,300	16,500
1 hour,	–	–	11,200	11,500
2 hours,	800	500	10,800	7,300
4 hours,	700	490	11,000	7,200
6 hours,	400	135	12,000	6,000
8 hours,	800	200	20,000	3,800
24 hours,	1,300	65	16,000	104
2 days,	1,044	120	6,500	400
3 days,	7,700	–	12,000	200
4 days,	103	763	1,200	42
6 days,	164	133	5,500	133
8 days,	245	156	5,400	40
10 days,	250	110	12,800	15
13 days,	275	25	300	7
15 days,	180	12	–	–
17 days,	792	13	–	–
20 days,	20	10	1,200	15
23 days,	2,590	9	–	–
28 days,	100	13	46	9
30 days,	260	13	–	–
34 days,	82	10	28	2
42 days,	90	12	11	0
48 days,	10	6	65	3
55 days,	3	1	6	0
64 days,	3	4	2	0
71 days,	5	6	–	–

TABLE No. 17. — *Water in Glass Vessels, containing Sheets of Metallic Copper.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Experiment No. 182.			Experiment No. 186.		
	Merrimack River Water.	Effluent Sewage Filter.	Driven Well Water.	Merrimack River Water.	Effluent Sewage Filter.	Driven Well Water.
Start,	1,600	14,500	900	2,400	2,000	195
1 day,	1,500	972	443	525	245	375
2 days,	1,600	4,300	3,400	545	345	560
3 days,	2,000	1,100	12,300	340	240	46,000
4 days,	7,500	32,500	6,175	3,500	370	87,300
5 days,	21,000	142,000	30,000	655	1,800	78,100
6 days,	4,400	22,000	5,110	240	1,420	78,100
7 days,	5,000	10,800	21,600	720	1,800	60,000
8 days,	–	–	–	900	11,200	43,000
9 days,	–	–	–	700	6,875	66,600
10 days,	–	–	–	6,000	12,000	100,000
11 days,	–	–	–	2,400	8,000	73,400
12 days,	–	–	–	585	63,000	70,000
13 days,	–	–	–	575	60,000	72,000
14 days,	–	–	–	3,200	4,750	69,000

TABLE No. 18. — *Merrimack River Water and City Water plus Sewage.*

[B. coli per cubic centimeter.]

Elapsed Time.	Experiment No. 175. Merrimack River Water.		Experiment No. 178. Tap Water containing 10 Per Cent. of Sewage.	
	Control in Stone Crock.	Copper Dish.	Control in Stone Crock.	Copper Dish.
Start,	11	11	2,600	5,000
1 day,	11	–	750	550
2 days,	11	0[2]	700	100
3 days,	+	0[2]	100	+
4 days,	+	0[2]	+	+
6 days,	+	0[2]	6	+
8 days,	5	0[2]	+	3
10 days,	+[1]	0[2]	1	6
13 days,	+[1]	–	2	+
15 days,	+[1]	–	0[2]	4
17 days,	0[2]	–	0[2]	3
20 days,	0[2]	–	0[2]	4
22 days,	–	–	0[2]	0[2]
24 days,	–	–	0[2]	0[2]

TABLE No. 19. — *Merrimack River Water.*

[B. coli per cubic centimeter.]

Elapsed Time.	Experiment No. 183.		Experiment No. 200.	
	Control in Enamelled Dish.	Copper Dish.	Control in Enamelled Dish.	Copper Dish.
Start,	32	44	–	–
½ hour,	–	–	91	146
1 hour,	–	–	118	114
2 hours,	48	10	118	97
4 hours,	23	12	120	96
6 hours,	48	+	74	63
8 hours,	44	12	105	15
24 hours,	30	+	52	+[1]
2 days,	0	3	8	+[1]
3 days,	25	4	8	11
4 days,	7	+	–	+[1]
6 days,	1	10	11	+[1]
8 days,	11	0[2]	+[1]	+[1]
10 days,	7	0[2]	+[1]	+[1]
13 days,	1	0[2]	+[1]	+[1]
15 days,	–	0[2]	–	–
17 days,	–	–	–	–
20 days,	+[1]	–	6	+[1]
23 days,	+[1]	–	–	–
28 days,	+[1]	–	0[2]	+[1]
30 days,	0[2]	–	–	–
34 days,	0[2]	–	0[2]	+[1]
42 days,	–	–	0[2]	0[2]
48 days,	–	–	0[2]	0[2]

[1] 1 c. c. = 0, 100 c. c. = +.   [2] 100 c. c. = 0.

Table No. 20. — *Forty-eight-hour Broth Culture of B. Coli, diluted 1 : 10,000 with Sterile Tap Water.*

[B. coli per cubic centimeter.]

Elapsed Time.	Experiment No. 184.		Experiment No. 189.	
	Control in Enamelled Dish.	Copper Dish.	Control in Enamelled Dish.	Copper Dish.
Start,	370,000	350,000	430,000	360,000
2 hours,	750,000	550,000	700,000	420,000
4 hours,	320,000	450,000	118,800	98,000
6 hours,	340,000	500,000	275,300	110,200
8 hours,	440,000	159,800	260,000	350,000
24 hours,	750,000	735	21,000	9,500
2 days,	390,000	2	77,800	190,800
3 days,	4,300,000	1	479,300	2,100,000
4 days,	–	–	2,851,200	180,000
5 days,	1,570,000	+	3,800,000	539,600
6 days,	4,700,000	+	1,430,000	400
8 days,	–	–	392,100	1
10 days,	–	–	2,750,000	0
12 days,	–	–	450,000	0

Table No. 21. — *Experiment No. 199. — Forty-eight-hour Broth Culture of B. Coli, diluted 1 : 10,000 with Sterile Tap Water.*

[B. coli per cubic centimeter.]

Elapsed Time.	Control in Enamelled Dish.	Copper Dish.	Elapsed Time.	Control in Enamelled Dish.	Copper Dish.
Start,	280,000	440,000	6 days,	639,000	1
½ hour,	280,000	380,000	8 days,	410,000	4,900
1 hour,	380,000	290,000	10 days,	1,560,000	750
2 hours,	360,000	300,000	13 days,	1,000,000	+ [1]
4 hours,	240,000	78,400	20 days,	170,000	+ [1]
6 hours,	291,600	68,400	27 days,	46,100	+ [1]
8 hours,	147,600	10,500	33 days,	229,000	+ [2]
24 hours,	111,600	15	40 days,	990,000	+ [2]
2 days,	146,900	+ [1]	47 days,	400,000	0 [3]
3 days,	1,026,000	+ [1]	54 days,	520,000	0 [3]
4 days,	852,000	22	62 days,	100,000	0 [3]

[1] 1 c. c. = 0, 10 c. c. = +. [2] 1 and 10 c. c. = 0, 100 c. c. = +. [3] 1, 10 and 100 c. c. = 0.

TABLE NO. 22.—*Experiment No. 190. Forty-eight-hour Broth Culture of B. Typhosus, diluted 1 : 10,000 with Sterile Tap Water.*

[B. typhosus per cubic centimeter.]

ELAPSED TIME.	Control in Enamelled Dish.	Copper Dish.	ELAPSED TIME.	Control in Enamelled Dish.	Copper Dish.
Start, . . .	180,000	270,000	6 hours, . . .	2,000	200
½ hour, . . .	200,000	93,600	8 hours, . . .	1,800	+
1 hour, . . .	47,000	39,000	24 hours, . . .	2,000	+ [1]
2 hours, . . .	26,500	14,500	2 days, . . .	330	0 [2]
4 hours, . . .	300	700	3 days, . . .	110	0 [2]

[1] 1–10 c. c. = 0, 100 c. c. = +. [2] 1–10–100 c. c. = 0.

COMPARISON OF COPPER AND COPPER SULPHATE WITH OTHER METALS AND SALTS.

In the following digest of experiments the various bottles of experiments with ferrous sulphate and aluminium sulphate are designated by the amount of iron or aluminium present in parts per 100,000.

Experiment No. 210.

Merrimack River water, treated with ferrous sulphate. Range, 0.002 to 2.01. Duration, one hundred and thirty-one days. The bacteria in the control increased during the first twenty-four hours, and then gradually decreased until the one hundred and sixteenth day, when a small secondary increase occurred. In 0.002, the increase in twenty-four hours was larger than in the control, and then the numbers decreased steadily throughout the period of observation. In 2.01, more than 95 per cent. of the bacteria were destroyed in twenty-four hours, but those remaining were able to increase steadily until the sixth day, after which a decline set in which lasted until the one hundred and ninth day. A slight secondary increase began about the one hundred and sixteenth day.

B. coli was found in gradually decreasing numbers in the control until the ninety-fifth day, and in 0.002 until the eighty-eighth day. In 2.01, B. coli was nearly destroyed in twenty-four hours, the organism being detected in 1-cubic-centimeter samples up to the fifth day, and in 10 cubic centimeters up to the thirteenth day. The bacterial results are shown in Table No. 23, and the B. coli results in Table No. 29.

Experiment No. 218.

Merrimack River water, treated with ferrous sulphate. Range, 0.020 to 20.1.

The bacteria in all the bottles increased steadily for a few days, then decreased slowly. The maximum was reached in the control, 0.020, and 20.1, on the fifth day; in 0.201, on the ninth day; and in 2.01, on the eleventh day. B. coli was found in the control in small numbers as late as the seventy-eighth day, and on the ninety-first day, in the waters which had been treated. The bacterial results are shown in Table No. 24, and the B. coli results in Table No. 30.

Experiment No. 158.

Merrimack River water, treated with sulphate of alumina. Range, 0.134 to 0.537. Duration, four days. The bacteria in all samples were reduced during the first twenty-four hours, and then began to increase about the third or fourth day. The results are shown in Table No. 25.

Experiment No. 165.

Merrimack River water, treated with sulphate of alumina. Range, 0.134 to 0.537. Duration, eleven days. The bacteria in the control increased to a maximum on the third day, and then declined. In all of the treated samples the bacteria were much diminished on the second day, but all showed a material increase from the third to the seventh days.

The B. coli results in this experiment are interesting, showing the occasional appearance of considerable numbers in all treated samples at intervals, with intermediate periods in which the test organism was not detected. This result was probably due to errors in sampling, caused by the precipitated aluminium hydrate, and would indicate that B. coli was able to live in the precipitate, and perhaps to increase. The bacterial results are shown in Table No. 26, and the B. coli results in Table No. 31.

Experiment No. 209.

One thousand cubic centimeters of Merrimack River water was placed in each of seven glass jars, and thin sheets of copper, aluminium, lead, zinc, tin and iron, respectively, were inserted into each of six jars, the seventh being retained as a control. Exposed metal surface, 625 square centimeters. Duration, one hundred and thirty-two days. The bacteria in the control showed a steady decrease after the first twenty-four hours. With the copper, the bacteria decreased during the first twenty-four hours and then increased to a maximum on the eighth day, dropping

off slowly until the twenty-third day. With the aluminium, there was a steady decrease in bacteria throughout the experiment. With the lead, the bacteria increased slightly to a maximum on the eighth day, remained practically constant until the twenty-third day, and then decreased steadily, with a slight secondary increase on the one hundred and fifth day. With the zinc, the bacteria increased slightly to a maximum on the sixth day, and then declined rapidly, the water becoming sterile on the twenty-seventh day. The bacteria decreased steadily in the water containing tin until the forty-first day, when a small secondary increase began, lasting until the one hundred and twenty-fifth day. With the iron, the bacteria decreased steadily, with small secondary increases from the seventeenth to the forty-eighth day and from the ninetieth to the one hundred and fifth day.

B. coli in all the samples decreased steadily, with the usual fluctuations, and disappeared in the presence of zinc on the tenth day, in the presence of iron on the fifteenth day, in the presence of tin and aluminium on the forty-first day and in the presence of copper on the forty-eighth day; from the control on the eighty-third day and in the presence of lead on the ninety-seventh day. The bacterial analyses are given in Table No. 27, and the B. coli determinations in Table No. 32.

Experiment No. 237.

Eleven hundred cubic centimeters of Merrimack River water, containing 1 per cent. by volume of sewage, was placed in each of seven jars, and thin sheets of copper, aluminium, lead, zinc, tin and iron were inserted into each of six of the jars, respectively, the seventh being retained as a control. The exposed metal surface in each case was 625 square centimeters. In the control, and in the waters containing lead and tin the bacteria decreased steadily throughout the period of observation. In that containing copper a large increase occurred during the first four days, after which the bacteria declined steadily. In the presence of aluminium the bacteria decreased steadily until the fifteenth day, when a secondary increase started, lasting until the twenty-third day. With zinc a considerable reduction occurred during the first twenty-four hours, after which the numbers increased until the third day, when a decline set in, lasting throughout the period of observation. With iron an increase occurred during the first twenty-four hours, after which a steady decrease was noted until the fifteenth day, when a secondary increase began which lasted until the twentieth day.

The number of B. coli in the control increased largely during the first twenty-four hours, after which it decreased steadily, until the water was practically sterile (after thirty-one days). In all of the jars con-

taining metals, B. coli decreased steadily, a slight secondary increase being noted on the seventeenth day in the water containing aluminium. The fluctuations in the number of B. coli were quite noticeable, in a number of instances no organisms being found in 1-cubic-centimeter samples for a number of days, and then appearing in small numbers. B. coli disappeared from the water which contained copper on the sixth day, from that containing zinc on the tenth day, from that containing tin on the fifteenth day, from those containing iron and lead, respectively, on the twenty-third day, and probably from that containing aluminium on the thirty-first day. The bacterial analyses are given in Table No. 28, and the B. coli determinations in Table No. 33.

TABLE NO. 23.—*Experiment No. 210. Merrimack River Water, to which was added .1 Per Cent. of Lawrence Sewage.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	Iron (Parts per 100,000)—		Elapsed Time.	Control.	Iron (Parts per 100,000)—	
		0.002.	2.01.			0.002.	2.01.
Start,	17,000	-	-	39 days,	190	205	410
1 day,	72,500	123,500	500	46 days,	110	245	305
2 days,	64,800	86,400	1,300	53 days,	95	90	260
4 days,	35,000	13,300	8,500	60 days,	65	90	95
5 days,	10,700	10,500	7,300	67 days,	75	110	46
6 days,	17,500	36,000	83,000	74 days,	170	75	250
7 days,	12,000	12,500	6,550	81 days,	21	57	28
8 days,	2,200	61,400	0	88 days,	140	110	85
11 days,	11,000	10,800	26,500	95 days,	120	12	67
13 days,	8,900	1,200	9,500	103 days,	38	8	18
15 days,	8,000	3,700	9,500	109 days,	55	100	80
18 days,	6,200	5,000	7,400	116 days,	1,100	180	700
21 days,	3,300	900	2,200	123 days,	1,100	375	275
25 days,	600	1,600	1,440	131 days,	500	170	1,200
32 days,	390	110	350				

TABLE No. 24. — *Experiment No. 218. Merrimack River Water.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	Iron (Parts per 100,000) —			
		0.020.	0.201.	2.01.	20.1.
Start,	600	-	-	-	-
1 day,	1,300	425	700	300	250
2 days,	600	500	44	85	130
3 days,	4,900	2,400	900	1,500	1,700
4 days,	-	-	-	-	-
5 days,	20,000	12,900	8,800	2,200	9,100
7 days,	7,700	2,000	9,700	1,400	400
9 days,	7,500	2,000	1,600	2,000	50
11 days,	2,100	300	1,400	15,400	0
15 days,	3,800	375	275	2,000	18
18 days,	2,200	1,400	800	2,800	600
21 days,	300	230	70	1,100	14
28 days,	140	230	120	600	5
35 days,	230	75	47	325	23
42 days,	16	50	130	190	11
49 days,	38	70	35	65	29
56 days,	21	51	47	31	16
63 days,	11	10	50	22	37
70 days,	35	12	36	17	52
78 days,	46	12	32	11	30
84 days,	108	65	37	72	30
91 days,	15	26	19	49	28

TABLE No. 25. — *Experiment No. 158. Merrimack River Water.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	Alumina (Parts per 100,000) —			
		0.134.	0.269.	0.403.	0.537.
Start,	950	-	-	-	-
6 hours,	800	20	255	110	145
1 day,	205	143	120	55	95
2 days,	-	248	176	155	70
3 days,	1,200	400	790	10	2,800
4 days,	-	2,800	3,800	20,000	4,700

TABLE NO. 26. — *Experiment No. 165. Merrimack River Water.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	Alumina (Parts per 100,000) —			
		0.134.	0.269.	0.403.	0.537.
Start,	1,450	–	–	–	–
1 day,	176,400	4,900	3,200	800	1,900
2 days,	321,900	550	290	110	125
3 days,	430,000	11,200	11,400	1,050	155
5 days,	129,000	25,800	4,600	1,700	260
7 days,	7,700	3,200	40,000	5,900	75,600
9 days,	15,500	1,600	26,300	3,000	25,500
11 days,	16,500	18,500	30,500	41,400	28,200

TABLE NO. 27. — *Experiment No. 209. Merrimack River Water.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	Copper.	Aluminium.	Lead.	Zinc.	Block Tin.	Iron.
Start,	10,000	75,600	14,600	18,000	9,000	75,600	7,700
4 hours,	11,000	700	11,000	12,700	4,100	15,200	18,000
8 hours,	19,200	180	15,500	9,300	6,200	24,000	14,700
24 hours,	9,700	430	8,500	2,900	5,200	14,000	5,500
2 days,	2,500	75,600	7,000	4,500	11,000	6,700	7,300
3 days,	800	850	5,000	24,000	14,500	4,300	1,400
4 days,	800	–	1,200	33,000	5,500	1,750	600
6 days,	1,000	360,000	600	30,800	28,500	1,700	65
8 days,	1,450	673,000	900	38,300	4,050	900	62
10 days,	250	97,200	150	2,000	650	700	29
13 days,	110	181,500	120	2,000	950	50	20
15 days,	125	108,000	65	21,400	450	55	80
17 days,	23	51,000	100	21,250	65	105	300
20 days,	250	59,000	85	22,500	7	45	110
23 days,	180	31,500	9	22,100	10	90	230
27 days,	43	0	8	800	0	43	10
34 days,	–	310	55	1,100	0	12	360
41 days,	180	10	10	1,200	–	43	175
48 days,	290	4	100	490	–	720	430
55 days,	225	2	35	400	–	770	60
62 days,	260	4	5	130	–	60	60
69 days,	200	0	0	55	–	70	80
76 days,	160	2	3	20	–	550	42
83 days,	350	10	0	10	–	375	47
90 days,	150	9	26	6	–	120	110
97 days,	125	4	12	14	–	210	220
105 days,	35	4	55	180	–	350	130
111 days,	75	30	65	500	–	350	75
118 days,	23	0	40	7	–	75	36
125 days,	38	13	60	19	–	260	100
132 days,	5	7	3	22	–	52	85

TABLE No. 28. — *Experiment No. 237. Merrimack River Water, containing 1 Per Cent. of Sewage.*

[Bacteria per cubic centimeter.]

Elapsed Time.	Control.	Copper.	Aluminium.	Lead.	Zinc.	Tin.	Iron.
Start,	44,500	-	-	-	-	-	-
1 day,	21,000	127,800	44,000	56,000	7,000	35,000	86,600
2 days,	150,000	362,100	16,500	26,000	13,400	12,000	16,500
3 days,	11,000	180,000	2,800	8,500	16,500	1,400	35,000
4 days,	4,600	305,000	11,500	8,500	10,500	4,800	18,000
6 days,	415	35,000	310	5,500	11,200	200	205
8 days,	2,800	96,300	220	3,500	3,700	138	93
10 days,	52	3,600	95	3,000	19	94	63
13 days,	69	6,700	55	155	115	18	8
15 days,	17	245	1,000	80	21	27	105
17 days,	23	790	7,600	3	100	105	760
20 days,	31	115	3,000	9	9	235	1,500
23 days,	5	100	3,850	18	40	275	525
28 days,	10	65	480	20	5	210	30
31 days,	25	275	325	135	116	160	125

TABLE No. 29. — *Experiment No. 210. Merrimack River Water, to which was added .1 Per Cent. of Lawrence Sewage.*

[B. coli per cubic centimeter.]

Elapsed Time.	Control.	Iron (Parts per 100,000) —		Elapsed Time.	Control.	Iron (Parts per 100,000) —	
		0.002.	2.01.			0.002.	2.01.
Start,	70	-	-	25 days,	8	10	0
1 day,	31	20	+	32 days,	0	5	-
2 days,	2	1	+	39 days,	3	1	-
4 days,	20	+	+	46 days,	3	5	-
5 days,	15	+	1	53 days,	0	3	-
6 days,	43	58	+ [1]	60 days,	4	2	-
7 days,	12	+	+ [1]	67 days,	0	+ [1]	-
8 days,	7	+	+ [1]	74 days,	2	1	-
11 days,	12	3	+ [1]	81 days,	0	+ [1]	-
13 days,	+	+ [1]	+ [1]	88 days,	4	5	-
15 days,	10	5	0	95 days,	1	0	-
18 days,	0	28	0	103 days,	0	0	-
21 days,	0	20	0				

[1] 1 c. c. = 0, 10 c. c. = +.

TABLE NO. 30. — *Experiment No. 218. Merrimack River Water.*

[B. coli per cubic centimeter.]

Elapsed Time.	Control.	Iron (Parts per 100,000) — 0.020.	0.201.	2.01.	20.1.
Start,	20	-	-	-	-
1 day,	26	15	6	2	3
2 days,	8	23	9	6	3
3 days,	19	9	15	20	4
4 days,	7	4	6	11	4
5 days,	3	4	0	2	3
7 days,	0	7	0	0	8
9 days,	3	0	2	14	0
11 days,	4	0	5	-	0
15 days,	11	16	6	6	7
18 days,	0	1	2	10	0
21 days,	0	2	0	0	0
28 days,	0	0	0	0	0
35 days,	15	6	3	0	0
42 days,	12	0	4	11	3
49 days,	3	3	1	2	5
56 days,	7	9	0	1	1
63 days,	1	4	0	0	0
70 days,	10	5	16	16	10
78 days,	8	11	4	6	1
84 days,	0	0	0	1	0
91 days,	0	15	14	17	3

TABLE NO. 31. — *Experiment No. 165. Merrimack River Water.*

[B. coli per cubic centimeter.]

Elapsed Time.	Control.	Alumina (Parts per 100,000) — 0.134.	0.269.	0.403.	0.537.
Start,	36	-	-	-	-
1 day,	6	0	0	0	0
2 days,	95	11	20	0	25
3 days,	65	1	16	0	0
5 days,	20	0	0	22	0
7 days,	25	0	0	0	0
9 days,	11	35	63	40	114
11 days,	0	0	0	21	0

TABLE NO. 32. — *Experiment No. 209. Merrimack River Water.*

[B. coli per cubic centimeter.]

ELAPSED TIME.	Control.	Copper.	Aluminium.	Lead.	Zinc.	Block Tin.	Iron.
Start,	32	52	18	19	5	4	25
4 hours,	18	47	38	14	35	32	15
8 hours,	1	2	+	1	7	6	+
24 hours,	12	3	+	+	+	10	6
2 days,	10	2	10	3	3	3	+
3 days,	+	+	10	+	5	+	+
4 days,	1	+	+	1	+	+	1
6 days,	5	4	6	12	+	4	+
8 days,	26	10	10	19	6	25	0
10 days,	9	3	+	+	0	9	0
13 days,	6	+	+	2	0	3	6
15 days,	1	+	2	3	0	3	0
17 days,	7	+	2	+	0	6	0
20 days,	8	+	3	10	0	16	0
23 days,	+	+	21	4	0	10	0
27 days,	3	4	9	2	0	13	0
34 days,	2	9	6	5	–	3	0
41 days,	5	3	0	3	–	0	0
48 days,	+	0	0	+	–	0	0
55 days,	2	0	0	12	–	0	0
62 days,	4	0	0	7	–	0	0
69 days,	–	0	0	+	–	0	0
76 days,	1	–	–	1	–	–	–
83 days,	0	–	–	+	–	–	–
90 days,	0	–	–	3	–	–	–
97 days,	–	–	–	0	–	–	–
105 days,	–	–	–	0	–	–	–

TABLE NO. 33. — *Experiment No. 237. Merrimack River Water, containing 1 Per Cent. of Sewage.*

[B. coli per cubic centimeter.]

ELAPSED TIME.	Control.	Copper.	Aluminium.	Lead.	Zinc.	Tin.	Iron.
Start,	3,500	3,500	3,500	3,500	3,500	3,500	3,500
1 day,	38,900	2	1,370	149	22	3,100	650
2 days,	250	–	200	0	0	100	50
3 days,	108	12	75	3	3	45	230
4 days,	25	25	21	12	2	20	125
6 days,	20	0	0	1	0	8	20
8 days,	13	2	8	0	4	7	5
10 days,	15	0	0	0	0	0	0
13 days,	3	0	5	5	0	6	1
15 days,	1	0	0	2	0	0	1
17 days,	1	0	125	7	0	1	25
20 days,	0	0	45	1	0	1	6
23 days,	4	0	7	0	0	0	0
28 days,	1	0	3	0	0	0	0
31 days,	0	0	0	0	0	0	0

RÉSUMÉ AND CONCLUSIONS.

(1) The tank experiments show that *Anabæna* can be aggregated by copper sulphate if the sulphate added to the water is rightly adjusted to the work required, that is, to the number of *Anabæna* in the water to be treated. The more important reservoir experiments not discussed in this report also show this to be true. The tank experiments indicate, moreover, that the addition of an excess of copper sulphate

results in the disintegration of the organisms and their dissemination throughout the water, causing marked turbidity.

(2) With the Massachusetts waters experimented with, copper sulphate has apparently little tendency to such changes as occur when aluminium sulphate is added to hard water, and sedimentation occurs very slowly. This is shown by the reservoir results, and also by the tank experiments described in this report. In most of these tank experiments there was generally only a very slow sedimentation of the copper, and this sedimentation was apparently caused largely by combination with, or adherence to, the heavier particles of organic matter present in the water, these particles slowly settling. As a general thing it can be said, judging from observations of the water treated and the results obtained, that the freer the water from matters in suspension, the more slowly does the copper settle.

(3) The various experiments upon the collection of copper sulphate by wood, sand, leaves, peat, etc., show that the copper adheres to, or combines with, these matters readily. These experiments also show that the greater the percentage of organic matter in the material with which the copper comes in contact, the greater, generally, the amount of copper taken out of solution by absorption, combination or adherence. These experiments also show that copper is given up from these bodies, especially those containing much organic matter, very slowly, but apparently quite steadily. It is apparent that on the slow disintegration or decay of organic matter with which the copper is in combination, or to which it adheres, the copper must again pass slowly into solution; that is, if the organic matters are in contact with the water. Judging from all these results, a reservoir once treated with copper sulphate may, during long periods, show the presence of copper in its water, owing to the passage of the copper into solution from the organic matter, etc., with which it has combined or adhered. In shallow reservoirs affected to their entire depth by the force of the wind, or in reservoirs the waters of which periodically turn over, much copper-bearing organic matter may be disseminated throughout the water or occur in layers of various periods after treatment with sulphate.

(4) The bacterial experiments can be divided into two classes: (*a*) experiments in which waters were treated with definite amounts of copper as copper sulphate; (*b*) experiments in which the water was placed in contact with metallic copper, and allowed to absorb an unknown amount of the same. In addition, experiments were made to compare the action of other salts frequently used in water purification, such as ferrous sulphate and aluminium sulphate, with copper sulphate, and also to compare the effect of other metals with that of metallic copper.

The results of these various bacterial experiments, with their controls, can be summarized as follows: —

Controls. — In three experiments with polluted water, one showed a gradual decrease in bacterial contents and the other two an increase, then a decrease, which was followed by a secondary increase after some time. In four experiments with stagnant water, carried on for a short time only, one showed a decrease, one an increase, one remained practically constant, and one increased and then decreased. In one experiment with driven well water, the bacteria increased, then decreased, and continued to fluctuate in number during the hundred and thirty-three days the experiment continued. In the experiment made with B. coli naturally present, the number gradually decreased, but the organism was found in 1-cubic-centimeter samples during ninety-five days. B. coli added to water as broth culture decreased and then increased. In three experiments with laboratory cultures of B. typhosus, in one the control was sterile after twenty-four hours, in another a sharp decrease was noted until the third day, when an enormous increase commenced, which lasted through twenty-eight days; and in the third the bacilli, which were present in large numbers, remained practically unchanged during fourteen days.

One Part Copper Sulphate to One Billion Parts of Water (.0000253). — In the experiment made, the bacteria followed the same course as the control.

One Part Copper Sulphate to One Hundred Million Parts of Water (.000253). — The behavior of the normal water bacteria was observed in five experiments, four with polluted water and one with stagnant water. In four of the experiments the bacteria followed the same curve as in the control; and in the fifth they were nearly all destroyed at first, but the few remaining were able to multiply extensively. In one experiment, B. coli naturally present acted much like the control, decreasing slowly, but persisting eighty-eight days. In one experiment with a laboratory culture, a rapid decrease occurred, and B. coli disappeared at the end of six days. Three experiments were made with laboratory cultures of B. typhosus. In one experiment, large numbers survived three days, although the control died out in twenty-four hours; in another, nearly all were killed in twenty-four hours, but the very few remaining were able to increase largely. In the third experiment, the organisms had become somewhat accustomed to life in water before the copper was added, and increased steadily in number during the ten days they were under observation.

One Part Copper Sulphate to Ten Million Parts of Water (.00253). — The normal bacteria were observed in eight experiments: four with

polluted water, three with stagnant water and one with deep well water. Three of the polluted waters acted like the control, but in the other nearly all the bacteria were destroyed at once; the few remaining, however, were able to increase rapidly. In the three stagnant waters, the bacteria increased, although they failed to do so in one of the stagnant water controls. B. coli naturally present in the water of one experiment decreased slowly, as it did in the control, but the number was usually larger than in the control. In one experiment with a laboratory culture the organisms were killed in three days. Two experiments were made with laboratory cultures of B. typhosus; in one, the test organisms disappeared from 1-cubic-centimeter samples in three days; and in another nearly all were killed in four hours, but some were demonstrable in 10-cubic-centimeter samples up to the twenty-eighth day. In one experiment with a culture of B. typhosus which had been grown four days in water, a steady increase occurred during the ten days it was under observation.

One Part Copper Sulphate to One Million Parts of Water (.0253). — The behavior of the water bacteria was observed in eight experiments: four with polluted water, three with stagnant water and one with deep well water. In two of the polluted waters, the bacteria followed the control, while in the other two they increased. In the three stagnant waters, the bacteria increased, although they decreased in one of the controls. The bacteria in the well water followed the control. The B. coli in the polluted water of one experiment decreased slowly, as in the control, but were more numerous than in the control. In one experiment with a laboratory culture, 1-cubic-centimeter samples yielded no organisms after two days. In one experiment with a laboratory culture of B. typhosus, the organism could not be detected in 1-cubic-centimeter samples after twenty-four hours. In another experiment, the organisms were nearly all destroyed in six hours, and a few were alive on the fifth day; but none were found in 100 cubic centimeters on the seventh day. In the experiment in which the typhoid bacilli were first inured to life in water, the numbers increased steadily during the ten days they were under observation.

One Part Copper Sulphate to One Hundred Thousand Parts of Water (0.253). — The bacteria were observed in seven experiments: four with polluted water, two with stagnant water and one with deep well water. In three of the polluted waters, nearly all of the bacteria were killed at once, but the few remaining were able to multiply largely. In the other polluted water, a large increase occurred at once. The numbers of bacteria in the two stagnant waters remained low for two days, and then increased rapidly. In the well water, the bacteria followed the same

curve as in the control. B. coli naturally present followed the same course as those in the control. With a laboratory culture of B. coli, the organism disappeared from 1-cubic-centimeter samples in twenty-four hours. In one experiment with B. typhosus, the organism disappeared from 1-cubic-centimeter samples in twenty-four hours. In another experiment, all but a few were killed in six hours, but 10-cubic-centimeter tests showed some to be alive on the sixth day. In the experiment with water-grown typhoid bacilli, the organisms disappeared from 1-cubic-centimeter samples in twenty-four hours.

One Part Copper Sulphate in Ten Thousand Parts of Water (2.53). — The total bacteria were observed in six experiments: four with polluted water and two with stagnant water. In two of the polluted waters, the bacteria decreased gradually, and the waters became practically sterile after eighty-nine and one hundred and thirty-one days, respectively. In one experiment, nearly all of the bacteria were killed immediately, and in another they were practically all destroyed at first, but a few remained during twenty days. The bacteria in the two stagnant water experiments were practically all destroyed in twenty-four hours. B. coli naturally present acted like the control, and remained alive after one hundred and three days. With a laboratory culture of B. coli, the organism disappeared from 1-cubic-centimeter samples in twenty-four hours. A laboratory culture of B. typhosus and the special water culture of the same organism did not show the presence of the organism after twenty-four hours when 1-cubic-centimeter samples were tested.

One Part Copper Sulphate to One Thousand Parts of Water (25.3). — The behavior of the normal bacteria was observed in three experiments with polluted water. Nearly all of the bacteria were destroyed in a short time in all of these experiments, but a few remained alive for ten days, twenty days and sixty-eight days, respectively. With a laboratory culture of B. coli and one of B. typhosus, the organisms were not found in 1-cubic-centimeter samples after twenty-four hours.

One Part Copper Sulphate in One Hundred Parts of Water (253.). — Two experiments were made with polluted water, in both of which all of the bacteria were killed in twenty-four hours.

The two experiments made with sulphate of alumina and ferrous sulphate seem to indicate that these salts are about as efficient in destroying bacteria as copper sulphate. Further experiments may contradict this, however.

Finally, it can be said that the use of any method of sterilization which is not absolutely sure and effective is dangerous in ordinary hands, tending to induce a false feeling of security, and leading to the neglect of ordinary precautions which otherwise would be taken.

The removal of bacteria, including B. coli and B. typhosus, by allowing water to stand in copper vessels for short periods, while occasionally effective, is not sure, and the time generally necessary to accomplish complete sterilization is long. The destruction of B. coli and B. typhosus is accomplished occasionally by dilute solutions of copper sulphate; but these organisms may live for many weeks in water containing copper sulphate in greater dilutions than 1 part in 100,000; and in order to be sure of the destruction of these germs, dilutions of 1 part in 1,000 must be used. Such an amount of copper as the last-mentioned gives a strongly astringent taste to water. In some instances, very dilute solutions of copper sulphate, or colloidal copper absorbed from contact with clean metallic copper, appear to have a decidedly stimulating effect on bacterial activity, causing rapid multiplication.

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1905.

Experiments upon the Purification of Sewage and Water at the Lawrence Experiment Station.[1]

By H. W. Clark, *Chemist of the Board.*

The following report includes the results of the work upon the purification of sewage and water at the station during the year ending Nov. 30, 1905. During this year a large number of filters were operated, and special studies carried out. Besides the work recorded in the following pages many chemical and bacterial analyses were made, as usual, of samples collected in connection with various investigations of the Board, and forwarded to the station.

The large sand filters, Nos. 1, 2, 4, 5B, 6, 9A and 10, were so operated during the year that better average yearly effluents were obtained than for a number of years. This result was accomplished by the combination of three factors: first, ridging and trenching Filters Nos. 1, 6 and 9A, as during the preceding year; second, application of a weaker sewage than for some years past, but much stronger than during the early years of operation of the station; and third, by protecting the trenches, to which the sewage is applied, by a covering of boards.

At the municipal filtration areas of the State, many of which are trenched and ridged in preparation for winter, the trenches during a considerable portion of each winter are roofed with ice, as has often been mentioned in these reports. These ice roofs form in consequence of application of large volumes of sewage at one point and slow passage of sewage into the filters. This ice roofing never forms on the filters at the station, owing to complete underdrainage, the small volume of sewage applied, etc.; although much ice has always formed upon and adhered to the surface sand during each winter that the filters have been exposed to the weather, and this ice has had to be removed from

[1] The work has been carried on under the general supervision of Hiram F. Mills, A.M., C.E., member of the State Board of Health, with the writer in direct charge. Mr. Stephen DeM. Gage and Mr. George O. Adams, the principal assistants of the writer at the station, have aided in the preparation of this report. A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the purification of sewage and water (1890). A similar account of the years 1890 and 1891 is contained in the twenty-third annual report of the Board for 1891. Since 1891 the results have been published yearly in the annual reports.

time to time during each winter, in order that the filters be kept in operation. (See notes in various reports.) The station filters have been still further exposed to the cold weather by the custom of removing all snow falling upon them. Upon the ice roofs over the trenches at the municipal areas and upon the board roofs over the trenches of these experimental filters during the past winter, the snow has accumulated and aided in keeping the filters warmer than they otherwise would have been, and has promoted satisfactory operation. It is evident, all things considered, that the method of operation followed with these filters during the past fifteen winters has not been conducive to the production of as efficient purification of the applied sewage as might have been obtained if ice coverings could have been formed, as at the municipal filtration areas; and the station filters have been more exposed to the cold than the municipal filters. Covering the trenches with boards, however, gives these experimental filters a winter surface protection about equal to that of the municipal areas.

The most interesting of the investigations at the station during 1905 was the continuation of that in regard to the organic matter which is removed from sewage by sand filtration, and which accumulates within sand filters instead of becoming oxidized rapidly within them, and, as a result of this oxidation, either passing away in the effluent or into the air.

Filters Nos. 265–269, inclusive, put into operation in May, 1904, for the purpose of aiding in the study of the nature of accumulated organic matter in sand filters, were continued in operation during a large part of 1905, and are described below, together with other small filters operated for information on other phases of the investigation. Further studies of this subject were made by means of analysis of samples of sand taken from the large filters, Nos. 1–10, inclusive. In this study, accurate determinations of the amount of carbonaceous matters deposited in these filters were made by the combustion process; that is, the ignition of the sand in an atmosphere of oxygen, the resulting carbonic acid gas being weighed. The fatty matters and the nitrogen present were also determined. In connection with this, a determination of the amount and nature of the sludge removed from the sludge beds at the Andover filtration area was made. Various other investigations were made, and are described in the following report.

Analyses of Sewage.

The sewage used at the station comes through a 2½-inch pipe about 4,400 feet long. The matters in suspension are well disintegrated by passage through this pipe, but as received at the station it is a strong

domestic sewage. The following tables present the result of the usual analyses of the various samples of sewage collected during the year: "Lawrence Street sewage" being the average of samples collected weekly from the sewer from which sewage is pumped to the station; "regular sewage" being the average of samples collected at the experiment station on at least four days of each week; "station sewage" being the average of samples of sewage as applied to nearly all the filters at the station; "sewage applied to Filters Nos. 1, 6 and 9A" being the average of samples collected from all sewage applied to these filters; and "average sewage" being the average of all sewage pumped on each Tuesday of the year.

Determinations of the total nitrogen and the nitrogen in solution were made by the Kjeldahl method during the year in all these samples, with the exception of the samples of sewage applied to Filters Nos. 1, 6 and 9A, in which only total nitrogen was determined by this method. The results of these Kjeldahl determinations, together with determinations of free and albuminoid ammonia, are given in the following tables: —

Lawrence Street Sewage.

[Parts per 100,000.]

Date.	Temperature (Deg. F.).	Ammonia.			Kjeldahl Nitrogen.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid. Total.	Albuminoid. In Solution.	Total.	In Solution.		Nitrates.	Nitrites.		
1904.											
December,	58	3.25	1.09	.67	3.21	2.31	11.37	.088	.0117	14.45	2,223,000
1905.											
January,	52	1.91	0.93	.58	2.95	2.24	8.67	.125	.0107	8.86	610,000
February,	51	2.16	0.93	.63	2.86	2.23	9.41	.076	.0103	8.29	1,628,000
March,	48	1.48	0.84	.51	2.69	1.61	8.11	.066	.0076	8.59	822,000
April,	57	2.22	1.04	.67	3.63	2.27	16.08	.146	.0100	11.47	1,390,000
May,	64	2.78	0.96	.60	2.87	2.13	9.33	.086	.0098	10.52	1,833,000
June,	69	3.30	0.86	.53	2.65	1.82	25.60	.089	.0090	10.71	1,627,000
July,	72	2.15	0.78	.49	2.11	1.28	14.35	.014	.0530	7.69	3,280,000
August,	74	2.56	0.79	.42	2.09	1.01	14.53	.063	.0135	7.30	1,676,000
September,	69	2.20	0.86	.60	2.26	1.54	13.56	.162	.0150	6.80	1,483,000
October,	66	2.63	0.90	.60	2.72	2.05	12.28	.061	.0133	7.92	1,815,000
November,	61	3.88	0.95	.56	3.27	1.66	10.05	.061	.0110	8.94	1,733,000
Average,	62	2.54	0.91	.57	2.78	1.85	12.78	.086	.0146	9.30	1,677,000

Regular Sewage.

[Parts per 100,000.]

Date.	Temperature (Deg. F.).	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Kjeldahl Nitrogen. Total.	Kjeldahl Nitrogen. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904.									
December,	45	5.88	1.23	.71	3.92	2.06	9.59	6.54	2,616,000
1905.									
January,	41	4.25	0.85	.54	1.93	1.13	10.07	7.44	1,241,000
February,	39	3.78	0.82	.57	1.56	1.02	11.76	6.06	1,463,000
March,	39	4.39	0.79	.53	1.43	1.05	11.93	5.63	940,000
April,	46	4.97	0.92	.47	1.90	0.92	17.66	5.84	2,159,000
May,	56	5.93	0.82	.38	1.60	0.65	19.85	5.35	1,791,000
June,	62	5.93	0.80	.33	1.48	0.59	14.67	5.47	1,757,000
July,	71	6.02	0.85	.38	1.46	0.65	20.34	4.83	1,721,000
August,	70	5.09	0.82	.37	1.57	0.69	15.57	4.37	1,330,000
September,	64	5.46	0.90	.46	1.73	0.84	16.78	4.19	2,042,000
October,	57	7.26	1.16	.52	2.24	0.97	16.63	4.97	2,216,000
November,	46	8.33	1.17	.53	2.41	0.99	13.37	5.70	2,862,000
Average,	53	5.61	0.93	.48	1.94	0.96	14.85	5.53	1,845,000

Station Sewage.

Date.	Temperature (Deg. F.).	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Kjeldahl Nitrogen. Total.	Kjeldahl Nitrogen. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1905.									
January,	52	2.98	0.58	.40	1.22	0.70	8.01	4.34	1,124,000
February,	54	3.51	0.62	.43	1.18	0.88	7.40	4.76	1,755,000
March,	49	3.05	0.58	.37	1.05	0.70	7.07	3.97	572,000
April,	52	3.81	0.75	.38	1.46	0.75	8.84	4.70	1,947,000
May,	58	3.16	0.49	.25	0.88	0.43	8.46	3.28	992,000
June,	63	2.93	0.44	.21	0.87	0.34	6.65	3.75	520,000
July,	75	2.95	0.41	.26	0.79	0.46	8.04	2.77	1,055,000
August,	71	2.51	0.44	.23	0.87	0.45	8.69	2.95	962,000
September,	64	4.33	0.72	.38	1.32	0.63	14.06	3.49	1,553,000
October,	57	4.41	0.74	.36	1.39	0.63	11.42	3.30	1,302,000
November,	47	3.95	0.56	.29	1.21	0.54	6.40	3.15	1,486,000
Average,	58	3.42	0.58	.32	1.11	0.59	8.64	3.68	1,206,000

Average Sewage.

[Parts per 100,000.]

Date.	Temperature (Deg. F.).	Ammonia.			Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid. Total.	Albuminoid. In Solution.	Total.	In Solution.			
1904.									
December,	45	4.90	0.87	.52	2.94	1.71	8.58	6.26	2,475,000
1905.									
January,	45	3.96	0.86	.50	1.89	1.10	8.67	7.88	1,330,000
February,	39	3.37	0.90	.58	1.67	0.97	14.87	5.60	1,870,000
March,	40	5.10	0.85	.54	1.59	1.08	11.67	5.58	635,000
April,	45	4.55	0.92	.51	1.91	0.95	24.04	6.39	1,265,000
May,	56	5.48	0.85	.39	1.59	0.64	16.66	5.61	1,743,000
June,	–	4.50	0.90	.38	1.64	0.60	15.05	7.00	2,320,000
July,	71	5.67	0.86	.36	1.47	0.61	15.45	4.68	2,457,000
August,	70	5.28	0.85	.36	1.86	0.67	19.99	4.27	1,788,000
September,	63	4.70	0.77	.36	1.54	0.66	17.37	4.56	2,017,000
October,	56	7.72	1.17	.52	2.63	0.91	14.66	5.46	2,400,000
November,	45	8.10	1.04	.48	2.49	0.94	15.50	5.51	2,080,000
Average,	52	5.28	0.90	.46	1.94	0.90	15.21	5.73	1,865,000

Sewage applied to Filters Nos 1, 6 and 9A.

[Parts per 100,000.]

Date.	Temperature (Deg. F.).	Ammonia. Free.	Ammonia. Total Albuminoid.	Kjeldahl Nitrogen.	Chlorine.	Oxygen Consumed.
1904.						
December,	58	3.07	.55	1.5400	5.74	4.45
1905.						
January,	–	2.23	.52	1.0885	6.18	4.28
February,	–	2.80	.50	.9930	6.90	4.27
March,	–	2.28	.41	.6730	5.95	3.38
April,	–	3.88	.67	1.3100	8.48	4.30
May,	–	3.85	.49	1.0650	8.61	3.70
June,	–	2.15	.45	.8000	8.65	3.38
July,	–	2.55	.38	.8000	8.64	2.59
August,	–	2.50	.39	.7200	8.70	2.77
September,	–	3.22	.56	.9300	11.99	3.31
October,	–	3.88	.56	1.2375	9.30	3.34
November,	–	4.88	.59	1.3175	8.75	3.85
Average,	–	3.11	.51	1.0395	8.16	3.64

Nitrogen Studies.

The nitrogen studies made during the year in continuation of those reported upon in 1904 were confirmatory to a large extent of the conclusions made at that time. Analyses of samples of sand from ridges in Filters Nos. 1, 6 and 9A and the operation of small filters of sand taken from the surface layers of these large filters have shown still more clearly the stable nature of the matter that has slowly accumulated during the many years of operation of the large experimental filters, and show conclusively that there is in the Lawrence sewage, and hence probably in all sewage, a small percentage of organic matter that is very resistant to some of the bacterial forces active in the purification of sewage, and that this matter slowly, but unceasingly, accumulates in sand filters that receive sewage of the nature of that at the station. At the filtration areas of the State, from the surface of which much organic matter, together with some sand, is from time to time removed, this matter accumulates more slowly; but at Brockton, during the past year, 7 inches, and at Clinton during 1904, 2 inches of surface sand were removed from all the beds.

The small experimental filters, Nos. 265–269, inclusive, constructed of clogged sand, and operated in such a way as to cause the bacterial forces to maintain their activity and rapidly remove accumulated organic matter, if this matter is of a nature similar to a large proportion of that in sewage, have failed to clear themselves of this matter; the carbonaceous matters have remained nearly constant or but slowly decreasing, and nitrification has been low within them, although active when easily decomposed nitrogenous matter, such as peptone, was added with the applied water. From all these filters, as explained in the last report, a considerable percentage of nitrogenous organic matter adhering to the sand was removed in a few months of operation; but during the remaining period of operation, up to the end of October, 1905, the nitrogen content of each remained practically stationary, notwithstanding favorable filtration conditions, — thus again showing the stable nature of this matter. The sand in the ridges of Filters Nos. 1, 6 and 9A has lost organic matter but slowly, and, owing to this ridging and the application of sewage to trenches, residual organic matter is in some instances accumulating at lower depths than when the surface of the filters was always level.

The following tables show the method of operation, the average analyses of the effluents, the nitrogen removed month by month from these filters in their effluents, the amount of nitrogen in the sand of each filter at different periods, and the amount of nitrogen that has been set free.

Filter No. 265.

Constructed of 1 foot in depth of sand from the surface of Filter No. 1.

Average Analyses.

[Parts per 100,000.]

1905.	Free Ammonia.	Nitrogen as		Bacteria per Cubic Centimeter.
		Nitrates.	Nitrites.	
January,	.0200	0.38	.0005	–
February,	.0200	0.26	.0033	–
May,	.1775	1.63	.0010	3,300
June,	.0471	0.28	.0006	13,567
July,	.0325	0.41	.0013	10,000
August,	.0650	0.84	.0000	12,933
September,	.0333	0.88	.0000	2,533
October,	.0200	0.55	.0000	3,600

Beginning Feb. 1, 1905, rate increased to 60,000 gallons per acre daily. Beginning February 10, filter received 1 per cent. settled sewage in canal water. May 22, filter started, after resting since March 1. Flooded with city water at rate of 30,000 gallons per acre daily. June 9, started to flood with city water containing 1 part of phosphoric acid per 100,000 and 0.5 part of potassium sulphate per 100,000. July 17, 0.77 parts of nitrogen from peptone added daily. July 29, applied water contained 0.95 parts nitrogen from peptone. Beginning October 2, flooded with city water.

Filter No. 266.

Constructed of 1 foot in depth of sand from the surface of Filter No. 6.

Average Analyses.

[Parts per 100,000.]

1905.	Free Ammonia.	Nitrogen as		Bacteria per Cubic Centimeter.
		Nitrates.	Nitrites.	
January,	.0200	.24	.0020	–
February,	.0267	.17	.0023	–
May,	.1450	.69	.0010	3,000
June,	.0543	.31	.0004	3,540
July,	.0300	.16	.0000	6,075
August,	.0750	.14	.0000	7,166
September,	.0150	.19	.0000	226

Feb. 1, 1905, rate increased to 60,000 gallons per acre daily. Beginning February 10, filter received 1 per cent. settled sewage in canal water. May 22, filter started, after resting since March 1. Flooded with city water at rate of 30,000 gallons per acre daily. June 9, started to flood with city water containing 0.5 part potassium phosphate, 0.5 part magnesium phosphate and 1 part potassium sulphate. July 17, seeded with 5 grams of sand from surface of Filter No. 6.

Filter No. 267.

Constructed of 1 foot in depth of sand from the surface of Filter No. 9A.

Average Analyses.

[Parts per 100,000.]

1905.	Free Ammonia.	Nitrogen as		Bacteria per Cubic Centimeter.
		Nitrates.	Nitrites.	
January,	.0150	0.21	.0015	–
February,	.0133	0.19	.0043	–
May,	.0525	1.62	.0007	11,000
June,	.0614	0.55	.0001	16,550
July,	.0375	0.75	.1450	1,525
August,	.0275	0.93	.0557	6,421
September,	.0200	0.99	.0917	5,750
October,	.0250	0.67	.0000	3,250

Feb. 1, 1905, rate increased to 60,000 gallons per acre daily. February 10, filter received 1 per cent. settled sewage in canal water. May 22, filter started, after resting since March 1. Flooded with city water at rate of 30,000 gallons per acre daily. June 9, started to flood with city water containing 1 per cent. sewage, 2 parts ammonium chloride and 4 parts sodium carbonate. July 11, stopped adding 1 per cent. of sewage. July 25, started to flood with city water containing 4.7 parts NH_4Cl and 8 Na_2CO_3 (1.48 NH_3). October 2, began to flood with city water.

Filter No. 268.

Constructed of 1 foot in depth of sand from the Clinton disposal area.

Average Analyses.

[Parts per 100,000.]

1905.	Free Ammonia.	Nitrogen as		Bacteria per Cubic Centimeter.
		Nitrates.	Nitrites.	
May,	.0600	.83	.0015	42,000
June,	.0729	.45	.0003	24,000
July,	.0275	.68	.0000	4,421
August,	.0250	.35	.0002	1,284
September,	.0675	.39	.0002	251

Feb. 1, 1905, rate increased to 60,000 gallons per acre daily. Beginning February 10, filter received 1 per cent. settled sewage in canal water. May 22, filter started, after resting since March 1. Flooded with city water at rate of 30,000 gallons per acre daily. June 15, started to flood with city water containing 0.77 parts nitrogen from peptone. July 11, stopped adding peptone.

Table showing the Approximate Amount of Nitrogen in Grams appearing in the Effluents of Filters Nos. 265 to 268, inclusive.

	Filter No. 265.	Filter No. 266.	Filter No. 267.	Filter No. 268.
1904.				
May,	.055	.012	.062	.006
June,	.082	.045	.023	.019
July,	.038	.035	.023	.014
August,	.017	.017	.004	.003
September,	.012	.011	.002	.005
October,	.009	.006	.002	.004
November,	.009	.005	.002	.004
December,	.007	.004	.003	.003
1905.				
January,	.005	.003	.003	.003
February,	.008	.006	.006	.005
May,	.008	.004	.007	.004
June,	.004	.005	.003	.001
July,	.001	.003	.005	.007
August,	—.0009	.002	—.004	.005
September,	—.0006	.003	—.003	.006
October,	.002	-	.002	-
Total,	.255	.161	.140	.089
Equivalent to parts nitrogen in sand.	37.67	32.20	26.17	15.00

Table showing Nitrogen in Sand Filters Nos. 265 to 268, inclusive, at Different Periods.

Total Nitrogen.

[Parts per 100,000.]

	Filter No. 265.	Filter No. 266.	Filter No. 267.	Filter No. 268.
1904.				
Start,	215.70	176.70	84.43	91.43
July 26,	63.65	78.70	61.58	63.65
August 29,	62.62	71.11	63.51	64.09
December 15,	64.40	78.88	64.50	57.30
1905.				
March 1,	64.19	-	56.73	53.47
July 10,	-	-	57.07	-
October 11,	50.62	83.47	58.45	57.00
Total parts nitrogen removed by filtration,	165.10	93.23	27.70 [1]	34.43
Parts nitrogen appearing in effluent as inorganic nitrogen,	37.67	32.20	26.17	15.00
Parts nitrogen removed as organic and free nitrogen,	127.43	61.03	1.53	19.43

[1] Using March 1 analysis.

Filters Nos. 271, 272, 273 and 274.

For a further confirmation of this work with Filter No. 265, etc., four other tube filters, constructed of clogged sand from Filter No. 1 or 9A, were operated during the year, namely, Filters Nos. 271, 272, 273 and 274.

Filter No. 271 was flooded with distilled water; Filter No. 272, with Lawrence city water; Filter No. 273, with city water plus 1 per cent. by volume of sewage; and Filter No. 274, with city water. Filter No. 274, constructed of sand from Filter No. 9A, had high nitrates in its effluent for a few days only; the effluents of the remaining filters contained large amounts of nitrates for several weeks, but, as in the experiments with Filters Nos. 265, etc., nitrification became low when about one-third of the organic matter was removed from the sand.

The following table summarizes the work of these filters: —

Summary.

	Filter No. 271.	Filter No. 272.	Filter No. 273.	Filter No. 274.
Parts nitrogen in sand at start of experiment,	96.06	96.06	96.06	105.40
Parts nitrogen in sand at end of experiment,	63.20	69.21	58.06	85.41
Parts nitrogen removed from sand,	32.86	26.85	38.00	19.99
Per cent. nitrogen removed from sand,	34.29	27.95	39.56	18.97
Parts nitrogen appearing in effluent,	30.06	21.41	30.31	8.95
Per cent. nitrogen appearing in effluent,	31.29	22.28	31.54	8.49
Parts nitrogen disappearing as free nitrogen,	2.80	5.44	7.69	11.04
Per cent. nitrogen disappearing as free nitrogen,	2.92	5.66	8.00	10.47
Per cent. total loss on ignition in sand at start of experiment.	2.68	2.68	2.68	2.49
Corrected per cent. loss on ignition in sand at start of experiment.	2.26	2.26	2.26	2.43
Per cent. total loss on ignition in sand at end of experiment.	2.23	2.14	2.16	1.92
Per cent. loss on ignition removed,	0.45	0.54	0.52	0.57
Per cent. of corrected loss on ignition removed,	19.91	23.40	23.01	23.46

Studies of the Organic Matter in Sand Filters Nos. 1 to 10, inclusive.

In the last report very complete studies were detailed in regard to the nitrogenous organic matter and organic matter determined by loss-on-ignition determinations, in the sand of Filters Nos. 1 to 10, inclusive. These studies were continued during 1905. The special object of this work during the past year was to examine more thoroughly into the nature of the organic matter that had accumulated in these filters, and also its rate of disappearance from such portions of the sand as by ridging or other means had been prevented for considerable periods from being an integral part of the working filter. Many determinations of the nitrogen in the sand in all parts of these filters were made during the year. Besides this, determinations were made of carbon and hydrogen by means of a combustion furnace, and also determinations of the fatty mat-

ters present. The following tables show the amount of nitrogen found on different dates, this nitrogen being, for purposes of comparison, determined both by the albuminoid ammonia and Kjeldahl methods.

A study of the tables will show that in almost every instance after the first rapid decrease in stored nitrogen following the trenching and ridging of the filters in 1904, nitrogen decrease has been exceedingly slow. Although slight fluctuations in the amount present are indicated, these fluctuations are probably due to the great difficulty of obtaining absolutely fair and uniform samples for examination. At the end of 1905 the sand in the ridges of Filters Nos. 1, 6 and 9A contained practically the same amount of nitrogenous matter as at the end of 1904, as shown by both albuminoid ammonia and Kjeldahl determinations. During the warm weather included in this period the filters had been levelled two or three times and sewage applied for a time to the entire surface, this being done in order that the worked over and easily nitrified nitrogenous bodies might be washed from the sand by the applied sewage, and that the sand might again become well seeded with sewage bacteria. The loss-on-ignition results, also given in these tables, show that the organic matter determined by this method remained practically constant during the past year. The fatty matters in the sand were also determined on different dates during the year, and the amounts found are shown in the table. When ridges were made again, they were, of course, formed of the same layers of sand as the previous ridges.

Analyses on Different Dates of Sand from Ridges of Filter No. 1.

[Parts per 100,000.]

Date.	Free Ammonia.	Albuminoid Ammonia.	Kjeldahl Nitrogen.	Kjeldahl Ratio.	Loss on Ignition.	Fats.
1904.						
October 10,	1.34	47.00	–	–	2.53	–
November 15,	1.47	45.90	78.42	55.3	2.43	–
1905.						
March 15,	1.63	48.38	–	–	2.42	–
April 25,	2.78	52.07	–	–	–	–
June 1,	1.99	55.76	86.40	52.9	2.52	–
June 22,	1.57	47.67	76.43	50.1	2.42	–
July 19,	1.68	54.15	84.94	52.3	2.81	59.5
August 24,	2.39	59.60	85.90	56.8	2.40	71.5
September 16,[1]	3.15	50.85	79.32	52.6	–	69.5
September 16,[2]	1.61	50.15	70.88	58.0	–	50.5

[1] Average upper 3 inches. [2] Average upper 6 inches.

Analyses on Different Dates of Sand from Ridges of Filter No. 6.

[Parts per 100,000.]

Date.	Free Ammonia.	Albuminoid Ammonia.	Kjeldahl Nitrogen.	Kjeldahl Ratio.	Loss on Ignition.	Fats.
1904.						
June 8, ...	–	118.50	–	–	–	–
August 8, ...	–	65.20	–	–	–	–
October 10, ...	1.98	76.72	–	–	4.01	–
November 15, . . .	2.34	68.69	101.7	56.5	3.32	–
1905.						
March 15, ...	2.51	67.30	–	–	3.20	–
April 25, ...	5.07	70.52	–	–	–	–
June 1, ...	1.85	78.98	124.1	52.2	3.45	–
June 22, ...	2.06	69.92	101.4	56.5	2.61	64.0
August 21, ...	1.90	72.40	116.4	53.2	3.19	74.0

Analyses on Different Dates of Sand from Ridges of Filter No. 9A.

[Parts per 100,000.]

Date.	Free Ammonia.	Albuminoid Ammonia.	Kjeldahl Nitrogen.	Kjeldahl Ratio.	Loss on Ignition.	Fats.
1904.						
June 8, ...	–	62.50	–	–	–	–
August 8, ...	–	55.00	–	–	–	–
October 12, ...	1.77	59.39	–	–	2.62	–
November 15, . . .	1.10	58.84	89.32	54.0	2.54	–
1905.						
March 15, ...	2.10	55.08	–	–	2.41	–
April 25, ...	2.15	57.40	–	–	–	–
June 1, ...	1.68	70.15	104.00	55.3	2.76	–
June 22, ...	2.37	55.31	85.17	53.3	2.93	72.5
July 10, ...	2.86	64.50	94.30	56.1	2.80	73.5
July 17, ...	2.43	66.15	93.56	55.4	2.85	73.0
September 13, . . .	2.68	57.35	83.64	56.2	2.56	49.0

Many examinations of samples of sand from the entire depth of Filters Nos. 1, 6 and 9A were made, in order to learn whether or not the method of trenching and ridging, and the consequent application of sewage to deeper layers of sand than when the surface remains level, causes an appreciable increase of stored organic matter in the filter below the ridges. The results of these analyses are given in the following tables, and show that on the whole there is not as yet such an increase: —

Nitrogen determined as Albuminoid Ammonia on Different Dates in Samples of Sand from Filter No. 1.

[Parts per 100,000.]

Date.	Depth in Inches.							
	9.[1]	12.	15.	18.	24.	36.	48.	60.
1903.								
November 23,	58.46	18.23	13.58	16.84	7.21	4.95	3.13	4.63
1904.								
October 10,	45.10	39.00	14.06	11.92	9.24	6.28	5.05	3.42
1905.								
March 23,	62.72	32.19	14.95	13.75	8.38	4.14	3.46	3.33
June 22,	33.03	14.80	12.45	13.66	6.19	5.06	4.32	4.51
August 24,	68.72	34.25	18.92	15.49	7.13	5.23	3.25	3.52
September 28,	46.89	34.96	23.17	17.25	8.94	6.14	4.92	3.41
October 27,	46.72	37.18	17.37	14.26	5.93	3.53	2.66	2.66

Kjeldahl Nitrogen. — Sand from Filter No. 1.

1905.								
March 23,	99.22	46.37	18.99	19.81	10.42	5.96	5.50	4.80
June 22,	49.69	20.48	18.74	19.98	9.32	7.53	6.51	7.13
August 24,	101.60	48.50	24.13	21.95	10.79	7.71	4.60	4.73
September 28,	71.12	51.54	36.93	25.48	12.45	9.08	7.10	5.04

Loss on Ignition. — Sand from Filter No. 1.

[Per Cent. by Weight.]

1904.								
October 10,	2.51	2.20	1.05	0.91	0.90	0.86	0.82	0.71
1905.								
June 22,	1.70	0.92	0.82	0.85	0.76	0.70	0.68	0.64
August 24,	1.75	1.15	0.85	0.83	0.82	0.68	0.65	0.65
September 28,	2.33	1.37	1.24	1.19	0.76	0.65	0.58	0.58
October 27,	2.19	1.54	0.92	0.82	0.65	0.54	0.56	0.61

Nitrogen determined as Albuminoid Ammonia on Different Dates in Samples of Sand from Filter No. 6.

[Parts per 100,000.]

Date.	Depth in Inches.						
	9.[1]	12.	15.	18.	24.	36.	48.
1903.							
December 5,	42.95	14.38	16.73	5.85	5.12	4.93	2.14
1904.							
October 10,	47.64	31.27	30.94	16.83	14.05	6.92	4.55
1905.							
March 28,	120.50	67.51	51.59	33.29	14.45	10.20	5.92
June 22,	41.14	19.30	14.09	11.38	12.48	5.87	4.26
September 28,	71.75	71.77	17.35	7.07	6.39	3.33	3.94
October 26,	70.11	28.60	11.00	9.98	7.33	5.56	4.40

[1] Three inches below surface of trenches.

Kjeldahl Nitrogen. — Sand from Filter No. 6.

[Parts per 100,000.]

Date.	Depth in Inches.						
	9.[1]	12.	15.	18.	24.	36.	48.
1905.							
March 28,	192.60	103.50	84.43	51.01	23.63	15.63	7.75
June 22,	65.24	33.64	22.37	18.45	19.72	9.08	6.75
September 28,	98.15	106.80	26.43	10.52	9.07	4.96	5.86

Loss on Ignition. — Sand from Filter No. 6.

[Per Cent. by Weight.]

1904.							
October 10,	2.82	2.07	1.97	1.43	1.33	1.08	0.85
1905.							
September 28,	3.07	3.13	1.35	0.90	0.92	0.72	0.79
October 26,	3.16	1.40	0.97	0.94	0.96	0.95	0.70

Nitrogen determined as Albuminoid Ammonia on Different Dates in Samples of Sand from Filter No. 9A.

[Parts per 100,000.]

Date.	Depth in Inches.							
	9.[1]	12.	15.	18.	24.	36.	48.	60.
1903.								
January 23,	–	12.40	–	7.12	5.58	4.81	4.95	4.66
November 30,	39.50	11.50	8.86	6.69	6.16	3.93	3.63	3.08
1904.								
October 12,	52.77	47.62	29.74	15.48	6.51	6.03	4.72	4.06
1905.								
March 22,	107.80	70.30	18.17	11.81	6.47	5.42	6.86	–
June 23,	52.65	18.49	10.72	8.05	6.64	4.54	4.31	4.52
September 13,	61.80	43.93	12.22	9.08	5.09	4.15	4.05	3.48
October 27,	65.82	51.25	11.15	9.25	5.46	4.38	3.75	3.91

Kjeldahl Nitrogen. — Sand from Filter No. 9A.

1905.								
March 22,	181.60	136.00	28.95	22.84	10.22	10.48	10.14	–
June 23,	82.87	26.77	16.88	13.65	10.44	7.82	6.80	7.24
September 13,	89.32	67.61	17.79	13.30	7.42	7.08	5.90	5.15

Loss on Ignition — Sand from Filter No. 9A.

[Per Cent. by Weight.]

1904.								
October 12,	2.53	2.08	1.39	0.94	0.64	0.62	0.59	0.58
1905.								
September 13,	2.84	2.16	0.68	0.62	0.54	0.51	0.50	0.69
October 27,	2.40	2.22	0.54	0.54	0.46	0.50	0.51	0.51

[1] Three inches below surface of trenches.

Further Studies of the Organic Matter in Sand Filters.

Carbonaceous Matters.

In the report of last year a chapter was given concerning the total organic matter stored in the large sand filters at the station, as determined by the loss in weight of sand from these filters when heated to a red heat for a considerable period. The amount of organic matter determined in this way was compared with the total amount of nitrogen present in each filter, and a table was given showing that the organic nitrogen present formed but a small percentage of the total organic matter; in fact, only about 2 per cent. of the total. During 1905 accurate determinations of the carbon and hydrogen of the organic matter stored in Filters Nos. 1, 6 and 9A were made by means of a combustion furnace, and the following tables give the carbon figures; and, for purposes of comparison, the determinations of organic matter by loss on ignition are also given in the same tables: —

Determination of Carbon and Loss on Ignition of Sand from Filter No. 1, Aug. 24, 1905.

Average Depth (Inches).	Per Cent.		Average Depth (Inches).	Per Cent.	
	Carbon.	Loss on Ignition.		Carbon.	Loss on Ignition.
6,	0.958	2.40	24,	0.084	0.82
9,	0.648	1.75	36,	0.067	0.68
12,	0.362	1.15	48,	0.046	0.65
15,	0.210	0.85	60,	0.045	0.65
18,	0.159	0.83			

Determination of Carbon and Loss on Ignition of Sand from Filter No. 6, Sept. 28, 1905.

3,	1.091	3.26	18,	0.115	0.90
6,	1.083	3.14	24,	0.092	0.92
9,	1.183	3.07	36,	0.080	0.72
12,	1.187	3.13	48,	0.121	0.79
15,	0.325	1.35			

Determination of Carbon and Loss on Ignition of Sand from Filter No. 9A, Sept. 13, 1905.

6,	0.992	2.56	24,	0.054	0.54
9,	0.987	2.84	36,	0.039	0.51
12,	0.521	2.16	48,	0.032	0.50
15,	0.137	0.68	60,	0.072	0.69
18,	0.117	0.62			

For further study and comparison, a table below gives the results of carbon analyses and loss-on-ignition determinations on a number of special samples, rich in organic matter, taken from the upper foot of

Filters Nos. 1, 6 and 9A. This table shows the per cent. of cellulose present in these sands, calculating from the actual amount of carbon found, and assuming that this carbon is exclusively from cellulose. An examination of the figures of the table shows how well this accounts for the organic matter found by the loss-on-ignition results. Of the twelve samples, the analyses of which are given in this table, the average loss on ignition is 2.14 per cent., and the average per cent. of cellulose present is 2.30, — that is, assuming, as previously stated, that this carbon represents cellulose. The table also presents figures showing the ratio of the carbon to the loss on ignition and the percentage of loss on ignition due to combined hydrogen, — that is, the hydrated silicates of the sand. From the figures given in this table it appears that, while cellulose contains 44.4 per cent. of carbon, 6.2 per cent. of hydrogen and 49.4 per cent. of oxygen, the carbonaceous organic matter in the filters contains 47.8 per cent. of carbon, 6.4 per cent. of hydrogen and 46.9 per cent. of oxygen.

Some of the variation noted in the results is due to errors in the corrections applied to the losses on ignition. Few sands are homogeneous, the different particles behaving differently on ignition; certain dark-colored particles are disintegrated into a fine powder, while other particles remain unchanged. That the per cent. of carbon in the organic matter in the sands is somewhat higher than in cellulose may be due to the presence of bodies similar to cellulose, but containing a greater per cent. of carbon. That perhaps most likely to be present is cutose, containing 68.3 per cent. carbon, and 9.0 per cent. hydrogen; it occurs in the outer covering of vegetables. The table follows: —

Results of Sand Combustions, showing the Similarity in Composition of the Carbonaceous Organic Matter in Sand from Sewage Filters and Cellulose.

Samples from Filter Number —	Depth. Average of Upper —	Per Cent. Carbon.	Per Cent. Hydrogen.	Per Cent. Loss on Ignition.	Per Cent. Cellulose if Carbon were calculated to Cellulose.	Per Cent. which Carbon is of Loss on Ignition.	Per Cent. which Hydrogen is of Loss on Ignition.
1,	3 inches,	0.947	.109	2.16	2.13	43.8	5.1
1,	6 inches,	0.958	.167	1.98	2.16	48.3	8.5
1,	6 inches,	1.051	.150	2.27	2.37	46.3	6.6
1,	9 inches,	0.648	.101	1.33	1.46	48.7	7.6
1,	9 inches,	0.930	.139	2.00	2.10	46.5	7.0
6,	3 inches,	1.091	.140	2.39	2.46	45.6	5.9
6,	6 inches,	1.180	.150	2.32	2.66	50.8	6.5
6,	6 inches,	1.083	.111	2.27	2.44	47.5	4.9
6,	9 inches,	1.183	.120	2.20	2.67	55.0	5.5
6,	12 inches,	1.187	.133	2.26	2.68	52.6	5.9
9A,	6 inches,	0.992	.154	2.10	2.24	47.0	7.4
9A,	9 inches,	0.987	.152	2.38	2.22	41.5	6.4

Corrections to be applied to Losses on Ignition in Sands.

In order to determine how much of the loss on ignition in clean sands is due to organic matter and how much to chemically combined water, combustions were made on the following clean sands: —

	Per Cent. of Carbon.	Total Per Cent. Loss on Ignition.	Correction due to Organic Matter.[1]	Corrected Per Cent. Loss on Ignition due to Combined Water.	Per Cent. Water Recovered during Combustion.
Clean sand from: —					
Filter No. 2, ...	.029	.460	.058	.40	.442 [2]
Filter No. 5, ...	.000	.320	.000	.32	.368
Filter No. 9A, . . .	.062	.460	.124	.34	.348
Clean sand A, ...	.015	.312	.030	.28	.347
Clean sand B, ...	.031	.515	.061	.45	.482

[1] In the sands from Filter No. 1, already analyzed, the carbon seems to be about 50 per cent. of the loss due to organic matter.

[2] Excess of water over that which would be formed from the hydrogen combined with carbon.

That the per cent. of water recovered is slightly greater than the corrected loss is due probably to the increase in weight of the sand due to oxidation of the iron therein. It will be seen that the correction to be applied varies with each sand, but is usually between 0.3 and 0.4 of 1 per cent.

Organic Matter per Foot in Filters Nos. 1, 2, 4, 6, 9A and 10.

Careful calculations have been made of the amount of organic matter per foot in Filters Nos. 1, 2, 4, 6, 9A and 10, and also the amount per acre, judging from the nitrogen found by the albuminoid ammonia determinations, Kjeldahl nitrogen and total organic matter as determined by loss on ignition, and carbon as determined by the combustion method. The first table following presents figures showing the total organic nitrogen present in each foot of material in these filters on different dates during 1904 and 1905. The nitrogen figures of this table show clearly that, notwithstanding the lowering of the amount of stored nitrogen in the upper layers of the filters during portions of 1904 and 1905, there really has been only a slow decrease since October, 1904; in fact, in the case of Filter No. 1, a slight increase is indicated by the last analyses, Sept. 28, 1905. The analyses of sand from all depths of Filters Nos. 2, 4, 6, 9A and 10 show, however, that less nitrogen was stored at the end of the summer of 1905 than at the end of the summer

of 1904, in all filters except No. 1. The loss-on-ignition results show the same fact. No carbon determinations were made, however, until 1905.

Table showing Amount of Organic Nitrogen, calculated from Albuminoid Ammonia, in Pounds per Acre, per Foot of Sand, in Large Filters Nos. 1, 2, 4, 6, 9A and 10.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
Filter No. 1.							
Oct. 10, 1904, . . .	3,007	752	424	341	231	4,755	63.2
March 23, 1905, . . .	3,236	768	280	234	225	4,743	68.2
June 22, 1905, . . .	2,418	649	342	291	305	4,005	60.4
Sept. 28, 1905, . . .	3,104	985	415	332	231	5,067	61.3
Filter No. 2.							
March 1, 1905, . . .	1,521	420	306	194	214	2,655	57.2
June 8, 1905, . . .	783	377	219	173	144	1,696	46.2
Filter No. 4.							
March 1, 1905, . . .	617	1,291	1,049	917	-	3,874	15.9
June 8, 1905, . . .	785	814	821	856	-	3,276	23.9
Filter No. 6.							
Oct. 10, 1904, . . .	4,281	1,398	509	335	-	6,523	65.6
March 28, 1905, . . .	5,945	2,098	751	435	-	9,229	64.4
June 22, 1905, . . .	3,691	930	432	314	-	5,367	68.8
Sept. 28, 1905, . . .	5,267	686	245	291	-	6,489	81.2
Filter No. 9A.							
Oct. 10, 1904, . . .	3,518	935	387	304	261	5,405	65.1
March 22, 1905, . . .	4,619	689	348	441	392	6,489	71.2
June 23, 1905, . . .	2,918	514	292	276	290	4,290	68.0
Sept. 13, 1905, . . .	3,540	505	266	260	223	4,794	73.9
Filter No. 10.							
March 23, 1905, . . .	3,751	1,355	793	940	-	6,839	54.8
June 27, 1905, . . .	3,533	910	928	777	-	6,148	57.5

Table showing Total Amount of Organic Matter in Pounds per Acre, per Foot of Sand, in Large Filters, as determined by Loss on Ignition.

Filter No. 1.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
Oct. 10, 1904,	108,740	41,849	38,279	36,498	31,602	256,968	42.3
June 22, 1905,	83,030	35,506	31,157	30,267	28,486	208,446	39.8
Aug. 24, 1905,	85,702	36,952	30,267	28,932	28,932	210,785	40.6
Sept. 28, 1905,	89,931	43,964	28,932	25,816	25,816	214,459	41.9

Filter No. 2.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
March 1, 1905,	45,762	25,774	24,821	24,401	32,815	153,573	29.8
June 8, 1905,	28,930	25,038	23,559	22,297	23,980	123,804	23.4

Filter No. 4.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
March 1, 1905,	37,564	55,685	63,101	61,065	-	217,415	17.3
June 8, 1905,	37,055	52,223	59,030	58,622	-	206,930	17.9

Filter No. 6.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
Oct. 10, 1904,	156,817	73,617	52,466	41,293	-	324,193	48.4
June 22, 1905,	102,763	49,805	48,094	39,350	-	240,012	42.8
Sept. 28, 1905,	153,091	49,685	34,978	38,378	-	276,132	55.4

Filter No. 9A.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
Oct. 10, 1904,	104,238	38,200	26,251	24,981	24,557	218,227	47.7
June 23, 1905,	114,187	27,831	24,557	24,134	35,989	226,658	50.3
Sept. 13, 1905,	107,105	25,186	21,593	21,170	29,215	204,269	52.4

Filter No. 10.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
June 27, 1905,	99,145	52,721	50,037	49,552	-	251,455	39.4

Table showing Amount of Carbon, in Pounds per Acre, per Foot of Sand, in Large Filters.

Filter No. 1.

Date.	First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.	Per Cent. of Total which First Foot yields.
Aug. 24, 1905,	32,560	5,980	2,980	2,050	2,000	45,570	71.4
Filter No. 6.							
Sept. 28, 1905,	55,210	7,581	3,886	5,878	–	72,555	76.1
Filter No. 9A.							
Sept. 13, 1905,	36,950	3,830	1,650	1,350	3,050	46,830	78.9

Table showing Amounts of Organic Matter, in Pounds per Acre, in Sand in Filters Nos. 1 to 10, inclusive, as determined by Different Methods.

Filter No. 1.

Date.	Nitrogen.				Loss on Ignition.		Carbon.
	As Free Ammonia.	Organic (Estimated).[1]	Total. Estimated.[1]	Total. Kjeldahl.	Total.	Accumulated.	
Oct. 10, 1904,	82	4,754	4,836	–	256,968	163,518	–
March 23, 1905,	134	4,743	4,877	–	–	–	–
June 22, 1905,	73	4,005	4,078	4,137	208,446	114,996	–
Aug. 24, 1905,	224	5,386	5,610	5,317	210,785	117,335	45,570
Sept. 28, 1905,	133	5,066	5,199	5,075	214,459	121,009	–
Filter No. 2.							
March 1, 1905,	263	2,655	2,918	3,132	153,573	84,173	–
June 8, 1905,	104	1,697	1,801	1,809	123,804	54,404	–
Filter No. 4.							
March 1, 1905,	262	3,874	4,136	4,158	217,415	28,535	–
June 8, 1905,	63	3,265	3,338	3,527	206,930	18,050	–
Filter No. 6.							
Oct. 10, 1904,	106	6,523	6,629	–	324,193	155,153	–
March 28, 1905,	176	9,229	9,405	–	–	–	–
June 22, 1905,	82	5,367	5,449	5,491	240,012	70,972	–
Sept. 28, 1905,	163	6,488	6,651	6,576	276,132	107,092	72,555

[1] Alb. N. × 1.85 = Organic N.

Table showing Amounts of Organic Matter, etc. — Concluded.

Filter No. 9A.

Date.	Nitrogen.				Loss on Ignition.		Carbon.
	As Free Ammonia.	Organic (Estimated).[1]	Total.		Total.	Accumulated.	
			Estimated.[1]	Kjeldahl.			
Oct. 10, 1904,	91	5,405	5,496	-	218,227	120,827	-
March 22, 1905,	192	6,488	6,680	-	-	-	-
June 23, 1905,	99	4,290	4,389	4,529	226,698	129,298	-
Sept. 13, 1905,	103	4,794	4,897	4,776	204,269	106,869	46,830

Filter No. 10.

Date.	As Free Ammonia.	Organic (Estimated).[1]	Total Estimated.[1]	Total Kjeldahl.	Loss on Ignition Total.	Loss on Ignition Accumulated.	Carbon.
March 23, 1905,	175	6,839	7,014	7,391	-	-	-
June 27, 1905,	91	6,149	6,240	6,450	251,455	169,855	-

[1] Alb. N. × 1.85 = Organic N.

Amount of Error in estimating Total Nitrogen and Organic Nitrogen in Sand from Albuminoid Ammonia Determinations.

Determinations of nitrogen by albuminoid ammonia and Kjeldahl methods in 574 samples of sand show that, if the albuminoid nitrogen be multiplied by 1.85, the product will closely approximate the amount of nitrogen as determined by the Kjeldahl method. While Kjeldahl determinations were made on a considerable number of the sands included in the tables, that determination was omitted in many instances; and it was considered fairer to use the value estimated from the albuminoid nitrogen in all cases, instead of the estimated nitrogen in some cases and the determined (Kjeldahl) nitrogen in others. In discussing these results it is well to know the errors which may be introduced by the use of such estimated nitrogen values.

In 137 of the sand analyses used in computing the tables, the nitrogen has been determined by the Kjeldahl method, and has also been estimated from the albuminoid nitrogen. A comparison of the nitrogen values obtained by both methods shows that 2 per cent. of the samples gave the same value and that the estimated nitrogen was greater than the Kjeldahl nitrogen in 42 per cent. and less in 56 per cent. The difference between the true value and the estimated value was less than 10 per cent. of the true value in more than 80 per cent. of the samples, and it was less than 5 in 55 per cent. The average difference in the 137 determinations was 6.5 per cent.

Study of Sludge.

At the Andover sewage area, as at most areas in the State, a very large amount of organic matter is removed from the sewage before it is passed to the sand filters. This is accomplished at Andover by means of screen chambers, followed by a settling tank having a capacity of 13,500 gallons, through which the sewage slowly flows. The sludge accumulating in this tank is run upon sludge beds about once each month. Beginning in July, 1905, observations were made of the amount of dry sludge taken from these beds, together with analyses of this sludge, and a following table presents the results of these observations and analyses. Between June and November 15 sludge was removed from the sludge beds six times, and the total dry weight of the same was in the neighborhood of 41,000 pounds, or 20½ tons. During that period of six months, or one hundred and eighty-five days, about 32,000,000 gallons of sewage passed to the filter area, and 1¼ tons of solid matter per million gallons of sewage were removed by means of a settling tank and sludge beds. The results of the analyses of this sludge are given in a following table, and show how small a percentage of this matter was nitrogen and how large a percentage was carbonaceous and fatty organic matter, the carbon being determined by the combustion furnace method, as previously noted in this report.

The Lawrence experimental filters always have received with the applied sewage all the matter removed at Andover and various other areas by means of settling tanks and sludge beds. In the station sewage this matter is well disintegrated, as stated many times in these reports.

Sewage Sludge discharged from the Andover Settling Tank.

1905.	Pounds of Dry Sludge.	Pounds of Various Bodies in Andover Sludge.			
		Nitrogen.	Fats.	Carbon.	Organic Matter, shown by Loss-on-ignition Results.
July 5,	4,839	59	761	1,447	2,657
July 21,	6,563	87	1,414	1,368	2,797
August 22,	6,501	109	1,029	1,764	3,205
September 19,	6,777	61	839	1,456	2,596
October 23,	9,840	188	1,905	2,981	5,254
November 14,	6,488	91	2,152	2,098	3,848
Total,	41,108	595	9,100	11,114	20,357
Percentage of,	-	1.45	21.14	27.04	49.52

Fats, Carbon and Total Organic Matter in Sludge and Sand from Filters.

The following table summarizes the results of a study of the comparative amount of fatty and carbonaceous matters and of total organic matter, as shown by loss on ignition, in the Andover sludge and in the upper portion of the sand in Filters Nos. 1, 6 and 9A. As shown by a preceding table, the fatty matters in the Andover sludge constitute a large percentage of the total organic matter present, varying from 29 to 56 per cent. in the various samples examined. These fatty matters, however, form but a very small percentage of the stable organic matters stored in the Lawrence filters, as shown by the figures given in the table following, in none of the samples examined being greater than five per cent. of the total organic matter, shown by loss-on-ignition results; and the maximum amount of fatty matter in any of the samples examined was only 7.4 per cent. of the carbon present.

Figures showing the Relation between Fats and Organic Matter in Andover Sewage Sludge and Sands from Experimental Sewage Filters at Lawrence.

Sample of—	Per Cent. of—				Ratio of Fats to Loss on Ignition.	Ratio of Fats to Carbon.
	Fats.	Carbon.	Hydrogen.	Loss on Ignition.		
Andover sludge, . . .	15.7	29.9	4.3	54.9	29.0	53.0
Andover sludge, . . .	21.6	20.9	2.9	42.6	51.0	103.0
Andover sludge, . . .	15.8	27.1	4.3	49.3	32.0	58.0
Andover sludge, . . .	12.4	21.5	3.4	38.3	32.0	58.0
Andover sludge, . . .	19.4	30.3	4.2	53.4	36.0	64.0
Andover sludge, . . .	33.2	32.3	4.7	59.3	56.0	103.0
Sand from Filter No. 1:—						
Average of 3 inches, .	0.070	0.947	0.109	2.16	3.2	7.4
Average of 6 inches, .	0.077	-	-	2.00	3.9	-
Average of 6 inches, .	0.060	-	-	2.39	2.5	-
Average of 6 inches, .	0.051	1.051	0.150	2.27	2.3	4.9
Sand from Filter No. 6:—						
Average of 6 inches, .	0.064	-	-	1.74	3.7	-
Average of 6 inches, .	0.074	1.180	0.150	2.32	3.2	6.3
Average of 6 inches, .	0.072	0.958	0.163	1.53	4.7	7.5
Sand from Filter No. 9A:—						
Average of 6 inches, .	0.073	-	-	2.47	3.0	-
Average of 6 inches, .	0.074	-	-	2.34	3.2	-
Average of 6 inches, .	0.073	-	-	2.39	3.1	-
Average of 6 inches, .	0.049	0.992	0.152	2.10	2.3	4.9

Raising Crops on Ridges of Filters Nos. 1, 6 and 9A.

During 1905 an experiment was tried on the removal of stored organic matter from Filters Nos. 1, 6 and 9A by raising crops upon them. On the ridges of Filter No. 1 a good growth of corn was obtained, although not planted until July 20; but beets and turnips planted on Filters Nos. 6 and 9A, respectively, failed to grow to any considerable size. On each filter only the ridges were used. A following table shows the total weight of dry matter in the corn raised on Filter No. 1, and also the composition of this matter. Since, however, in the growth of corn a large percentage of the carbon and some of the nitrogen needed is taken from the air, the figures of carbon and nitrogen given do not indicate that this amount was taken from the sand, although considerable organic matter must have been so taken, — not enough, however, to be shown by sand analyses.

Analysis of Corn from Filter No. 1.

Total grams of dry matter,	7,502.00
Per cent. of nitrogen,	2.43
Per cent. of carbon,	29.26
Grams of nitrogen,	182.00
Grams of carbon,	2,196.00
Per cent. loss on ignition,	90.60

Studies of Methods of Analysis.

In the report for 1904 many data were given concerning methods of analysis, especially for the correct determination of nitrogen in sewage, and of the amount of suspended matter in the effluents of sewage filters. The importance of the former determination has long been recognized, and a correct knowledge of the character of the suspended matter is of much importance in the study of the results that can be obtained by the newer methods of sewage purification. During 1905 the turbidity readings were continued, and the results are given in each of the tables of average analyses of effluents that are presented in a subsequent portion of this report. More than 2,200 Kjeldahl determinations of the total organic nitrogen present in sewage and the effluents of sewage filters were made during the year. The results of the analysis of each sample of sewage collected throughout the year are given in the tables of average analyses of sewage. During only four or five months of the year, however, was each sample of effluent analyzed by this method; hence these analyses, given in comparison with the albuminoid ammonia determinations on duplicate samples, are presented in the following tables. In these tables the average results of the albuminoid ammonia and Kjeldahl determinations are given, and also the results showing the greatest and least divergence. These results, as was expected, show

that the percentage of nitrogen that can be determined by the albuminoid ammonia method is a varying percentage of that actually present in the samples under examination; but that, averaging all the results, the amount of actual organic nitrogen that can be determined in this way in the effluents of sewage filters is about 45 per cent. of the total amount present.

Average Analyses.

Intermittent Sand Filters.

	Albuminoid Ammonia.	Kjeldahl Nitrogen.	Ratio of Albuminoid Nitrogen to Kjeldahl Nitrogen.
Filter No. 1,	0.0637	0.1144	45.7
Filter No. 2,	0.0791	0.1276	52.1
Filter No. 4,	0.0235	0.0409	46.7
Filter No. 5B,	0.0737	0.1514	40.1
Filter No. 6,	0.0772	0.1404	47.7
Filter No. 9A,	0.0543	0.1070	42.4
Filter No. 10,	0.0506	0.0936	44.3
Filter No. 100,	0.1174	0.2164	41.9
Filter No. 224,	0.0530	0.0892	48.1
Filter No. 242,	0.0307	0.0655	39.7
Filter No. 249,	0.0617	0.1192	42.3
Filter No. 250,	0.0546	0.0924	48.8
Filter No. 252,	0.0484	0.0832	48.8

Contact Filters.

Filter No. 175,	0.1849	0.3486	44.9
Filter No. 176,	0.2054	0.4282	41.1
Filter No. 221,	0.2264	0.4877	38.8
Filter No. 251,	0.2293	0.5091	38.2

Intermittent-continuous or Sprinkling Filters.

Filter No. 135,	0.2142	0.3597	48.6
Filter No. 136,	0.2847	0.5128	45.2
Filter No. 222,	0.4398	0.8490	44.0
Filter No. 233,	0.3129	0.6866	38.5
Filter No. 235,	0.2228	0.4165	44.4
Filter No. 247,	0.3888	0.8397	38.9
Filter No. 248,	0.3779	0.8228	38.8

Determinations of Oxygen consumed.

Ever since the determinations of organic matter by the oxygen consumed method, so called, have been made at the experiment station, the two-minute period of boiling has been adhered to, while at the laboratory of the Board in Boston the five-minute period has always been used.

The method gives at best only an indication of the amount of organic matter of a certain class in water, and for purposes of comparison, one arbitrary period answers as well as another; but since it is intended hereafter to use the five-minute period in both laboratories, more than six

hundred of the station samples were tested during the year by both the two-minute and the five-minute method. The object of this was to obtain a factor that always could be used in future, when comparisons of analyses in previous years are made with those to be made after Dec. 1, 1905. The results of this work performed during the year are given in following tables, and show that between 70 and 80 per cent. as much oxygen is consumed in the two-minute as in the five-minute period.

Summary.

Samples from —	Number of Samples examined.	Average [1] Per Cent. that Oxygen Consumed in Two-minute Period is of Oxygen Consumed in Five-minute Period.
River water,	18	79.6
Water filters,	82	78.3
Sand sewage filters,	159	70.3
Trickling filters,	75	71.2
Contact filters,	52	74.9
Lawrence street sewage,	20	70.7
Station sewages,	169	76.1
Septic sewages,	34	77.6

[1] Average of the averages for each filter and sewage.

Comparisons with the Palmer method also have been made with certain sewages and effluents, and the results are shown in the following table: —

Ratio of Oxygen-consumed Results by the Two-minute Boiling Method to Results by the Palmer Method (Thirty Minutes in a Boiling Water Bath).

Thirty-six Samples of Sewage.

52.5	59.8	66.7	52.4	48.5	59.3
52.0	46.2	47.8	56.5	46.7	66.9
72.6	43.9	44.0	77.4	45.0	75.5
68.5	53.4	41.0	61.0	55.0	56.7
64.1	55.8	46.9	60.5	45.8	60.0
47.6	58.6	45.6	52.3	52.0	62.2

Average, ... = 55.5
Maximum, ... = 77.4
Minimum, ... = 41.0

Ratio of Oxygen-consumed Results by the Two-minute Boiling Method to Results by the Palmer Method (Thirty Minutes in a Boiling Water Bath).

Filter Effluents.

	Filter No. 135.	Filter No. 136.	Filter No. 175.	Filter No. 235.	Filter No. 247.
Average,	44.2	50.4	50.2	49.5	55.6

Comparative Studies of the Matter depositing as Sediment in the Effluents of Sewage Filters of Coarse Material and in Sewage.

During the year, about 100 samples of the mixed organic and mineral matter that is present in suspension in sewage and in the effluent of coarse filters were examined and analyzed, in order, if possible, to determine the reason why the sewage sludge is so putrescible and the effluent sediment so stable. In these analyses, determinations of the amount of sediment per liter in the sewage and effluents were made, taking, in all instances, samples of the sewage passing to the filters. The results of all these analyses are given in a following table. The filters, the sediments in the effluents of which were studied, were Nos. 135, 136, 175, 235 and 247. All these filters except 247 showed efficient nitrification throughout the year. Filters Nos. 135, 136 and 175 produce, almost invariably, effluents that are non-putrescible by the usual incubation tests; Filter No. 235 an effluent that is generally non-putrescible; but Filter No. 247 gives a less well-oxidized effluent. The chief difference between the sediment of the filter effluents and the sewage sludge, as noted by these analyses, was the smaller percentage loss upon ignition, the total amount of nitrogen determined by both the albuminoid ammonia and the Kjeldahl methods being very similar in both sediment and sludge. The following table summarizes this work: —

Analyses of Sediments from Sewage and Sewage Effluents by Indirect Methods (calculated from the Difference between Filtered and Unfiltered Determinations).

Sewage Sludge.

Sewage Sludge from Sewage for Filter No. —	Grams. Sediment per Liter.	Per Cent. Loss on Ignition.	Per Cent. Albuminoid Ammonia, Dry Sediment.	Per Cent. Kjeldahl Nitrogen, Dry Sediment.	Kjeldahl Ratio.	Per Cent. Oxygen Consumed (Palmer's), Dry Sediment.
135,	.155	67.8	1.24	2.55	40.1	10.67
136,	.095	72.8	1.32	2.89	39.1	10.74
175,	.065	75.0	1.35	2.74	40.2	13.38
235,	.091	66.5	1.31	2.27	48.4	12.06
247,	.118	64.2	1.21	2.33	42.6	17.44
Average,	.105	69.3	1.29	2.56	42.5	12.86

Effluent Sediment.

135,	.082	66.9	0.70	1.15	49.3	15.08
136,	.086	57.9	1.35	2.64	42.9	16.95
175,	.068	53.0	1.25	2.55	52.6	13.74
235,	.037	49.8	1.54	2.71	41.1	25.06
247,	.121	58.8	1.69	4.54	36.2	16.78
Average,	.079	57.3	1.33	2.72	44.4	19.52

Relation between Carbon, Fatty Matters, etc., in Sewage Sludge and in the Effluents of Intermittent or Sprinkling Filters.

In a further study of the different character of the sludge deposited when sewage is allowed to stand and the sediment from effluents of trickling filters, a separation of the different grades of material in sewage sludge was made by elutriation after periods of sedimentation varying from thirty minutes to five hours; the percentage of the total amount of matter settling in each period and also the nature of this material being noted. Elutriations were made of sediment from fresh Lawrence street sewage and from stale station sewage. The sediment from Lawrence street sewage was obtained by allowing 30 gallons of the sewage to stand for six hours. The residue containing much of the suspended matter showed upon analysis 867 parts per 100,000, a loss on ignition of 600 parts and a fixed residue of 267 parts. For elutriation 2.17 grams of dry sediment were taken. The sediment from station sewage was obtained by allowing 20 gallons of sewage to stand for six hours. The sludge showed upon analysis a total residue of 654 parts per 100,000, a loss on ignition of 455 parts, and a fixed residue of 199 parts. Of the dry sediment 1.6 grams were used for elutriation. Tables showing these results follow; and it will be noted that the sediment with the strongest odor was the fine matter which settled only after periods of from two to five hours.

Further study of the samples of sludge collected from the Andover sludge beds, sludge from regular sewage and sediment from intermittent-continuous or sprinkling Filters Nos. 135 and 136 and contact Filters Nos. 137 and 221, showed that, while the fats in the Andover sludge and the Lawrence Experiment Station sewage sludge constituted from 12 to 33 per cent. of the total dry weight of the sludge, the fatty matters in the effluents of the sprinkling filters were very small in amount, varying from 0.12 to 2.37 per cent. by weight of the total amount of sediment, and the same was true of the sediment in the effluents of the contact filters. In these filters there is a rapid oxidation or bacterial destruction of the fatty matters in the applied sewage, this destruction, perhaps, accounting to a considerable extent for the difference between the keeping and odor-producing qualities of sewage sludge and filter sediment.

Further studies showed that the Andover sludge and the Lawrence sewage sludge contained enough fatty matters to account for a considerable percentage of the carbon present, varying, of course, as the amount of fatty matters varied, and actually varying from 7.7 to 20.6 per cent. On the other hand, while the *percentage* of the carbon in the filter sediments was often as great as the *percentage* of carbon in the sewage sludge,

this carbon did not represent any considerable portion of fatty matter. The loss on ignition of the Andover sludge and station sewage sludge, compared with the loss on ignition of the filter sediments, also showed the same distinction. In the Andover sludge and in the Lawrence sewage sludge the fatty matters accounted for from 27 to 56 per cent. of the total loss on ignition of these sludges; while in the sediments from the filters the fatty matters accounted for from 0.36 of a per cent. to 9.62 per cent. of the loss. Tables showing this follow: —

Lawrence Street Sewage Sediment.

Time of Settling.	Nature of Sediment.	Odor of Sediment.	Weight of Sediment Settling (Grams).	Per Cent. of Total by Weight.
30 minutes,	Coarse paper, etc.,	Slight,	.250	11.5
1 hour,	Coarse,	Slight,	.192	8.9
1.5 hours,	Medium,	Slight,	.295	13.6
2.0 hours,	Medium fine,	Strong — oily,	.273	12.6
5.0 hours,	Fine,	Strong — oily,	.399	18.4
Residue,	Fine,	Strong — oily,	.729	33.6

Station Sewage Sediment.

Time of Settling.	Nature of Sediment.	Odor of Sediment.	Weight of Sediment Settling (Grams).	Per Cent. of Total by Weight.
30 minutes,	Coarse paper, etc.,	Slight,	.456	27.9
1 hour,	Coarse,	Slight,	.188	11.5
1.5 hours,	Medium,	Slight,	.150	9.2
2.0 hours,	Medium fine,	Slight,	.143	8.7
5.0 hours,	Fine,	Slight,	.126	7.7
Residue,	Fine,	Strong — oily,	.475	29.1

Figures showing Relation between Fats and Organic Matter in Sewage Sludge and Sediment from Contact and Trickling Filters.

Sample of —	Per Cent. of —				Per Cent. which Fats are of Loss on Ignition.	Per Cent. of Carbon in Fats.	Per Cent. which Carbon in Fats is of the Total Carbon.
	Carbon.	Hydrogen.	Fats.	Loss on Ignition.			
Andover sludge,	29.9	4.3	15.7	54.9	29.0	9.7	32.5
Andover sludge,	20.9	2.9	21.6	42.6	51.0	13.4	64.1
Andover sludge,	27.1	4.3	15.8	49.3	32.0	9.8	36.2
Andover sludge,	21.5	3.4	12.4	38.3	32.0	7.7	35.8
Andover sludge,	30.3	4.2	19.4	53.4	36.0	12.0	39.7
Andover sludge,	32.3	4.7	33.2	59.3	56.0	20.6	63.7
Fats — sewage sludge,	62.0	11.7	–	–	–	–	–
Regular Lawrence sewage sludge,	34.0	4.3	20.8	58.6	35.5	12.9	37.9
Regular Lawrence sewage sludge,	42.5	5.7	25.6	75.4	33.9	15.9	37.4
Lawrence street sewage sludge,	40.3	5.9	20.2	74.5	27.1	12.5	31.1
Sediment from Filter No. 136,	13.7	2.3	0.12	32.9	0.36	0.07	0.005
Sediment from Filter No. 137,	18.6	2.9	0.41	38.7	1.06	0.25	0.013
Sediment from Filters Nos. 135 and 136,	22.2	3.3	2.37	43.8	5.41	1.51	6.6
Sediment from Filter No. 221,	16.6	2.7	3.36	34.9	9.62	2.10	12.5

Large Sand Filters in Operation at the Station. — Filters Nos. 1 to 10, inclusive.

For discussion of manner of operation of these filters during 1905, especially in regard to protection, from winter weather, equal to that upon municipal filtration areas, see pages 341 and 342.

Filter No. 1.

Filter No. 1 is constructed of 60 inches in depth of coarse sand of an effective size of 0.48 millimeter, and is 1/200 of an acre in area. On Dec. 24, 1904, the trenches in the filter were covered with boards; on Feb. 13, 1905, there was a thin scum on the surface of the trenches, and very little frost; and the trenches were raked one inch deep. The surface sand in the trenches was raked one inch deep three times in March, five times in April, four times in May, twice in June and once a week during the remainder of the year. On March 9, boards covering the trenches were removed; 2 inches to 9 inches of frost were found over one-fourth of the surface of the filter. On March 22, 5 inches of snow were removed from the filter; on April 30, the surface was levelled and dug over to a depth of 8 inches; on May 31, the surface was trenched in the same way as during the winter, except that the trenches ran at right angles. On July 17, applied sewage was changed to 300 gallons daily; on July 20, Indian corn was planted in ridges; on September 16, when the corn was from 3½ to 4½ feet high, it was pulled up. The total weight of corn was 164 pounds. Trenches dug more than 6 inches deep; ridges levelled and thoroughly mixed. On November 8, 5 trenches, 1 foot wide and 8 inches deep, were made on the surface; and 1 trench, 1 foot wide and 8 inches deep, cutting the other trenches at right angles through the center. Trenches located differently than before.

Filter No. 2.

Filter No. 2 is 1/200 of an acre in area, and is constructed of 60 inches in depth of fine sand of an effective size of 0.08 millimeter, with circular trenches 1 foot wide and 2 feet deep, of medium sand of an effective size of 0.19 millimeter, the surface of these trenches being below the surface of the remainder of the filter, and to them the sewage is applied. The surface of the trenches was raked 1 inch deep once during January, once during February, twice during March, five times in April, four times in May, twice in June and once each week during the remainder of the year. During January, 22½ inches of snow and 7/8 inch of ice were removed from the filter; during March, 7 inches of snow were removed. On January 26, the trenches were covered with

boards. On February 13, there was a thin scum on the surface of the trenches, and very little frost. March 9, boards removed; no frost in trenches; from 12 to 24 inches of frost in ridges. Trenches were dug over 1 foot deep on May 31. July 17, applied sewage changed to 200 gallons daily. Grass and weeds removed from entire surface. On November 8, trenches dug 1 foot deep; on December 1, the trenches were raked 1 inch deep and covered with boards.

Filter No. 4.

Filter No. 4, $1/200$ of an acre in area, is constructed of 60 inches in depth of fine river silt of an effective size of 0.04 millimeter, with circular trenches about 14 inches wide and 12 inches deep, of coarse sand of an effective size of 0.48 millimeter. The surface of these trenches is below the remainder of the filter, and to them the sewage is applied. The trenches were raked 1 inch deep twice during January, three times in March, five times in April, four times in May, twice in June and once each week during the remainder of the year. On January 25, the trenches were covered with boards. On March 9, the boards were removed; no frost in trenches; 12 to 18 inches of frost in ridges. On May 31 and November 8 trenches were dug more than 1 foot deep. The amount of sewage applied was changed to 200 gallons every other day on July 17; also grass and weeds were removed from the entire surface. During January, 23 inches of snow and $1/4$ inch of ice were removed from the filter; during March, 4 inches of snow were removed. On Dec. 2, 1905, the trenches were raked 1 inch deep and covered with boards.

Filter No. 5B.

This filter, $1/200$ of an acre in area, was constructed of 60 inches in depth of a mixture of cinders and ashes from the combustion of soft coal. It was first put into operation on March 5, 1898. The surface of the filter was raked 1 inch deep three times in March, five times in April, four times in May, twice in June and once during July. During January, $37 1/2$ inches of snow and $1/4$ inch of ice were removed from the filter; during February, 8 inches of snow and $1 1/4$ inches of ice were removed; and during April, 8 inches of snow were removed. On April 30, the surface was levelled and dug over to a depth of from 8 to 10 inches. On May 31, the surface was again trenched, except that the trenches were run at right angles to those previously dug. On July 11, the filter was put out of operation, the underdrains were washed out, and the tank was filled with 5 feet 2 inches of coarse sand. Filter to be now known as 5C. Two hundred gallons of station sewage applied daily.

Filter No. 5C.

This filter, 1/200 of an acre in area, was started on July 20, 1905. Two hundred gallons of sewage were applied daily. Surface raked 1 inch deep once during July and once each week during the remainder of the year. On August 1, sewage applied was increased to 300 gallons daily. On November 27, 5 trenches, 1 foot wide and 3 inches deep, were made on surface; 1 trench, 1 foot wide and 3 inches deep, cut the other trenches at right angles through the center. On Dec. 2, 1905, the trenches were raked 1 inch deep and covered with boards.

Filter No. 6.

This filter, 1/200 of an acre in area, is constructed of 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. Trenches were covered with boards on Dec. 24, 1904. The surface of the filter was raked 1 inch deep once during February, three times in March, five times in April, four times in May, twice in June and once each week during the remainder of the year. On February 13, there was a thin scum on the surface of the trenches; very little frost. On March 9, the boards were removed; 6 inches of frost were found along the south side of the tank, in a ring about 9 inches wide. On May 31, the surface was trenched the same as during the winter, except that trenches ran at right angles to those previously dug. On July 17, the volume of sewage applied was changed to 300 gallons daily. On August 22, the trenches were dug over to a depth of 6 inches, ridges were levelled and sand thoroughly mixed. On November 8, 5 trenches, 1 foot wide and 8 inches deep, were made on the surface, one trench, 1 foot wide and 8 inches deep, cutting the other trenches at right angles through the center. The trenches were located differently. During March, 8 inches of snow were removed from the filter. On Dec. 2, 1905, the trenches were raked 1 inch deep and covered with boards.

Filter No. 9A.

This filter, 1/200 of an acre in area, is constructed of 5 feet in depth of sand of an effective size of 0.17 millimeter. Trenches were covered with boards Dec. 30, 1904. The surface of the filter was raked 1 inch deep once during February, three times in March, five times in April, four times in May, twice in June and once each week during the remainder of the year. During March, 7 inches of snow were removed from the surface of the filter. March 9, the boards were removed; 2 to 8 inches of frost were found in a ring 1 foot wide on south side of

filter. On April 30, the surface was levelled and dug over to a depth of from 8 to 10 inches. On May 31, the surface was trenched the same as during the winter, except that trenches were run at right angles to those previously dug. On July 17, the volume of sewage applied to the filter was changed to 300 gallons daily. On September 16, the trenches were dug over 6 inches deep, ridges were levelled and the surface sand thoroughly mixed. On November 8, 5 trenches, 1 foot wide and 8 inches deep, were made on the surface, one trench, 1 foot wide and 8 inches deep, cutting the other trenches at right angles through the center. Trenches located differently. On Dec. 2, 1905, the surface was raked 1 inch and the trenches were covered with boards.

Filter No. 10.

This filter, $\frac{1}{200}$ of an acre in area, is constructed of 5 feet in depth of mixed fine and coarse sand of an effective size of 0.35 millimeter. No underdrains are beneath the sand except directly above and around the outlet pipe. A partition extending 3 feet below the surface separates the quarter of the surface which is farthest from the underdrains from the remainder of the surface. To this quarter the sewage is applied, and over the remainder of the surface is a layer of loam 8 inches in depth. The surface of the filter was raked 1 inch deep three times in March, five times in April, four times in May, twice in June and once each week during the remainder of the year. During January, 36½ inches of snow and 3¾ inches of ice were removed from the filter; during February, 10 inches of snow, 2 inches of water and 6¼ inches of ice were removed; during March, 8 inches of snow and ¼ inch of ice were removed; also some water on March 9. On April 30, that part of the surface to which the sewage is applied was dug over to a depth of from 3 to 4 inches. On October 9, 4 inches of sand were removed. Sand that was removed last fall was put back. On November 8, the surface was dug over from 6 to 8 inches deep.

Effluent of Filter No. 1.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Length of Time Sewage remained on Surface.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December,	55,500	57	41	5h. 17m.	0.8	.41	1.2667	.1000	5.19	1.92	.0075	.80	16,967
1905. January,	69,200	53	38	2h. 15m.	0.6	.30	0.7350	.0713	5.12	2.05	.0127	.57	14,700
February,	56,300	53	38	9h. 34m.	0.1	.30	0.6000	.0560	6.42	1.46	.0109	.82	6,900
March,	75,000	52	39	33m.	0.2	.30	0.8067	.0627	6.28	1.60	.0119	.55	13,900
April,	75,000	54	47	25m.	0.1—	.21	0.4650	.0537	7.57	3.25	.0130	.44	2,800
May,	72,200	58	56	2m.	0.1—	.20	0.1131	.0432	8.94	4.02	.0009	.50	3,400
June,	14,400	64	–	3m.	–	–	–	–	–	–	–	–	–
July,	61,700	73	71	6m.	0.1—	.17	0.2391	.0356	9.96	3.46	.0033	.44	6,800
August,	60,000	71	70	3m.	0.1—	.15	0.0589	.0251	8.36	3.19	.0003	.34	4,600
September,	60,000	64	67	6m.	0.1—	.16	0.0764	.0291	9.94	3.19	.0007	.30	5,000
October,	60,000	57	60	6m.	0.1—	.17	0.0705	.0324	11.16	4.72	.0000	.33	2,500
November,	55,400	56	49	7m.	0.5	.30	0.7278	.0648	8.33	1.91	.0101	.52	13,900
Average,	59,600	59	52	1h. 33m.	0.1	.24	0.4690	.0522	7.93	2.80	.0065	.51	8,315

Effluent of Filter No. 2.

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Length of Time Sewage remained on Surface.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December,	37,000	54	41	3h. 4m.	0	.17	1.1800	.0440	8.13	1.85	.0272	.47	1,283
1905. January,	42,300	53	37	4h. 41m.	0	.16	1.1117	.0353	3.80	1.17	.0353	.35	6,250
February,	43,800	55	36	9h. 13m.	0	.34	1.0500	.0760	5.12	0.29	.0198	.75	2,600
March,	33,300	53	37	1h. 58m.	0.1	.82	1.5683	.0920	5.60	0.14	.0115	.83	375
April,	24,000	52	45	37m.	0	.29	2.0133	.0693	7.07	2.77	.0143	.56	201
May,	24,100	59	53	10m.	0.1—	.21	1.2588	.0450	8.34	4.87	.0041	.47	132
June,	3,800	63	–	3m.	–	–	–	–	–	–	–	–	–
July,	31,500	73	67	9m.	0	.12	0.2484	.0246	11.04	5.50	.0010	.32	142
August,	40,000	70	70	5m.	0	.09	0.0066	.0164	8.68	3.31	.0001	.21	24
September,	40,000	64	67	17m.	0	.10	0.0023	.0161	8.19	3.05	.0000	.18	339
October,	40,000	57	59	15m.	0	.09	0.0039	.0160	10.80	4.43	.0000	.18	253
November,	36,900	55	50	13m.	0	.06	0.0089	.0136	7.67	3.88	.0007	.14	54
Average,	33,100	59	51	1h. 44m.	0	.22	0.7684	.0408	7.31	2.84	.0104	.41	1,059

Effluent of Filter No. 4.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Length of Time Sewage remained on Surface.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December, .	23,000	55	44	4h. 19m.	0	.11	.0657	.0140	10.13	4.21	.0256	.19	600
1905. January, .	23,100	53	38	8h. 45m.	0	.07	.2233	.0193	4.20	1.50	.0283	.21	1,467
February, .	22,900	54	37	12h.	0	.09	.3700	.0300	4.60	0.96	.0200	.26	2,950
March, . .	22,200	53	37	2h. 47m.	0	.08	.5933	.0213	4.92	1.46	.0252	.20	62
April, . .	26,000	52	43	38m.	0	.09	.7190	.0343	5.47	3.39	.0673	.14	143
May, . .	24,100	56	53	22m.	0	.10	.1308	.0209	7.52	4.68	.0080	.26	19
June, . .	5,800	64	–	3m.	–	–	–	–	–	–	–	–	–
July, . .	20,800	73	67	7m.	0	.10	.0249	.0149	6.88	4.20	.0004	.18	610
August, . .	20,700	71	69	4m.	0	.03	.0069	.0115	7.68	3.18	.0000	.17	36
September, .	20,000	64	65	6m.	0	.03	.0034	.0130	7.09	3.32	.0000	.12	151
October, . .	20,000	57	58	3m.	0	.04	.0029	.0109	8.47	3.76	.0000	.10	385
November, .	18,500	53	48	6m.	0	.04	.0041	.0117	8.30	3.08	.0000	.11	33
Average, .	20,600	59	51	2h. 25m.	0	.07	.1949	.0183	6.84	3.07	.0159	.18	587

Effluent of Filter No. 5B.

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Length of Time Sewage remained on Surface.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December, .	65,200	58	45	47m.	1.0	.91	2.6167	.1340	8.87	1.35	.0037	1.34	53,050
1905. January, .	76,900	58	41	2h. 32m.	0.9	.45	1.3583	.0747	5.33	1.56	.0031	0.83	21,600
February, .	70,000	60	40	3h. 52m.	0.2	.37	1.4400	.0750	6.60	1.69	.0120	0.61	12,900
March, . .	77,000	58	41	1h. 9m.	0.8	.43	0.8267	.0713	5.88	1.86	.0038	0.65	31,400
April, . .	80,000	52	49	33m.	0.1–	.26	0.8707	.0490	7.82	4.18	.0046	0.47	3,200
May, . .	77,000	57	56	3m.	0.1–	.21	0.3069	.0538	8.23	5.44	.0003	0.50	4,400
June, . .	18,500	64	–	4m.	–	–	–	–	–	–	–	–	–
July, . .	80,000	71	68	14m.	1.0	.18	0.3760	.0442	8.80	4.24	.0025	0.38	8,050
Average, .	68,100	60	49	1h. 9m.	0.5	.40	1.1136	.0717	7.36	2.90	.0043	0.68	19,200

Effluent of Filter No. 5C.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Length of Time Sewage remained on Surface.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1905.													
July,	40,000	72	67	1m.	0.1—	.10	.0028	.0180	10.10	0.40	.0080	.26	–
August,	60,000	70	71	1m.	0.1—	.07	.0031	.0133	7.66	2.00	.0107	.18	1,217
September,	57,700	64	67	3m.	0.1—	.05	.0020	.0135	7.54	2.95	.0001	.15	2,200
October,	60,000	57	61	3m.	0	.12	.0049	.0153	9.67	4.69	.0007	.15	460
November,	53,100	55	50	4m.	0.1	.10	.0499	.0221	8.03	2.53	.0010	.20	7,748
Average,	54,200	64	63	2m.	0.1—	.09	.0125	.0164	8.60	2.51	.0041	.19	2,906

Effluent of Filter No. 6.

Date.	Quantity Applied.	Sewage.	Effluent.	Length of Time.	Turbidity.	Color.	Free.	Total Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904.													
December,	52,600	56	39	4h. 55m.	0.2	.23	0.8533	.0593	4.96	1.35	.0079	.46	14,400
1905.													
January,	69,200	56	39	6h. 8m.	0.1	.29	1.0050	.0607	4.76	1.31	.0255	.53	11,400
February,	55,400	54	39	6h. 10m.	1.7	.44	1.0867	.1213	6.24	0.97	.0131	.63	36,200
March,	59,600	53	40	2h.	0.1	.24	0.7133	.0553	5.85	1.74	.0177	.47	7,700
April,	61,600	51	48	1h. 38m.	0.1—	.31	0.7913	.0690	7.44	2.78	.0433	.56	6,400
May,	67,400	58	56	8m.	0.1—	.24	0.4646	.0468	7.66	4.64	.0075	.47	4,200
June,	16,200	64	–	21m.	–	–	–	–	–	–	–	–	–
July,	59,600	73	70	14m.	0.1—	.20	0.2343	.0450	7.95	3.82	.0266	.36	15,300
August,	60,000	70	72	6m.	0.1—	.17	0.0679	.0232	7.71	3.13	.0024	.23	1,575
September,	57,700	64	66	7m.	0.1—	.10	0.0490	.0224	7.57	3.43	.0001	.23	1,850
October,	60,000	57	58	5m.	0	.13	0.0491	.0213	10.57	4.65	.0000	.21	1,233
November,	53,100	55	49	27m.	0.8	.26	0.8291	.0713	8.93	1.83	.0134	.51	19,600
Average,	56,000	59	52	1h. 52m.	0.2	.24	0.5585	.0541	7.24	2.70	.0143	.42	10,896

Effluent of Filter No. 9A.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Length of Time Sewage remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
1904. December, .	48,900	61	45	7h. 12m.	1.2	.49	1.3167	.1000	6.71	1.13	.0021	.84	13,400
1905. January, .	61,900	59	42	5h. 48m.	0.4	.33	1.0500	.0680	4.46	1.56	.0095	.64	16,500
February, .	49,600	54	42	16h. 50m.	0	.27	0.4500	.0450	5.98	1.79	.0012	.52	2,300
March, . .	59,600	54	41	2h. 8m.	0.1—	.28	0.3967	.0440	5.48	1.22	.0008	.58	3,000
April, . .	64,400	54	48	1h. 26m.	0	.22	0.3177	.0443	8.90	3.81	.0009	.47	60
May, . .	67,400	59	56	25m.	0.1—	.22	0.1948	.0375	11.18	4.21	.0005	.42	380
June, . .	16,200	64	–	10m.	–	–	–	–	–	–	–	–	–
July, . .	59,600	73	71	21m.	0	.12	0.0416	.0237	8.68	3.53	.0006	.28	170
August, . .	60,000	70	70	21m.	0	.09	0.0049	.0207	8.13	3.18	.0000	.27	82
September, .	60,000	64	66	37m.	0	.10	0.0204	.0237	8.71	3.28	.0002	.25	175
October, .	60,000	57	59	7m.	0	17	0.1747	.0252	12.12	3.32	.0000	.28	67
November, .	55,400	57	49	29m.	0.3	.42	0.9577	.0767	9.17	1.66	.0026	.60	14,300
Average, .	55,300	61	54	3h.	0.2	.25	0.4477	.0463	8.14	2.61	.0017	.47	4,585

Effluent of Filter No. 10.

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Length of Time Sewage remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
1904. December, .	16,700	56	46	3h. 54m.	0.1	.25	1.4750	.0540	7.80	1.70	.0122	.60	1,083
1905. January, .	22,100	54	42	4h. 57m.	0.1	.25	0.6933	.0460	4.42	1.23	.0023	.47	3,900
February, .	18,800	54	40	16h. 20m.	0.1	.33	0.5900	.0600	4.93	0.60	.0149	.56	6,350
March, . .	19,500	52	39	3h. 18m.	0.2	.33	0.6133	.0640	3.51	0.79	.0047	.56	3,200
April, . .	23,000	54	48	1h. 3m.	0.1—	.25	0.5660	.0590	11.73	2.27	.0023	.55	3,050
May, . .	24,100	59	54	8m.	0.1—	.20	0.2128	.0398	9.13	2.98	.0010	.39	625
June, . .	5,800	64	–	1m.	–	–	–	–	–	–	–	–	–
July, . .	23,100	73	68	2m.	0	.11	0.0544	.0261	9.42	3.58	.0002	.32	414
August, . .	25,000	70	69	2m.	0.1—	.09	0.0240	.0197	8.12	3.03	.0001	.21	125
September, .	25,000	64	66	6m.	0.1—	.10	0.0175	.0194	8.90	2.87	.0000	.24	165
October, . .	25,000	57	58	17m.	0	.15	0.0315	.0207	10.80	3.09	.0000	.23	96
November, .	23,100	56	51	25m.	0	.14	0.5027	.0323	9.37	3.10	.0041	.27	169
Average, .	20,900	59	53	2h. 33m.	0	.20	0.4346	.0401	8.01	2.29	.0038	.40	1,743

Operation of Septic Tanks.

During the year four septic tanks were in operation at the station, namely, Tanks A, F, G and H.

Septic Tank A was first put into operation in 1897, and the results obtained by it have been discussed in each report since that date. During 1905, the sewage was approximately thirty-six hours in passing through this tank.

Septic Tank G was put into operation in May, 1904, and was so operated during 1905 that the sewage was eight hours in passing through; while through Septic Tank H, of the same capacity and also put into operation in May, 1904, the sewage was approximately twenty-four hours in passing. The following table shows the average analyses of the sewage entering and the effluents from these tanks: —

Sewage applied to Septic Tank A.

[Parts per 100,000.]

	Temperature (Deg. F.).	Free Ammonia.	Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Total.	In Solution.			
Dec. 1, 1904, to Nov. 30, 1905, inclusive,	58	3.26	1.21	0.64	8.58	3.90	1,163,000
Effluent of Septic Tank A.							
Dec. 1, 1904, to Nov. 30, 1905, inclusive,	61	4.05	0.76	0.44	9.80	2.98	923,000
Sewage applied to Septic Tank G.							
Dec. 1, 1904, to Nov. 30, 1905, inclusive,	59	3.15	2.78	2.04	9.34	3.93	1,161,000
Effluent of Septic Tank G.							
Dec. 1, 1904, to Nov. 30, 1905, inclusive,	59	3.31	0.86	0.53	8.31	3.20	737,500
Sewage applied to Septic Tank H.							
Dec. 1, 1904, to Nov. 30, 1905, inclusive,	59	3.12	1.25	0.60	8.65	4.04	1,310,000
Effluent of Septic Tank H.							
Dec. 1, 1904, to Nov. 30, 1905, inclusive,	58	3.54	0.80	0.58	9.08	2.86	901,000

Septic Tank F continued in operation throughout the year, and received the heavy sludge resulting from allowing sewage to stand for sedimentation. This sludge was applied at such a rate that it was five days in passing through the tank. A table of analyses follows: —

Sewage applied to Septic Tank F.

[Parts per 100,000.]

	Temperature (Deg. F.).	Free Ammonia.	Kjeldahl Nitrogen. Total.	Kjeldahl Nitrogen. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Dec. 1, 1904, to Nov. 30, 1905, inclusive,	60	4.15	1.86	0.79	8.48	4.63	1,970,000

Effluent of Septic Tank F.

Dec. 1, 1904, to Nov. 30, 1905, inclusive,	64	5.29	0.61	0.27	9.73	2.45	555,000

Sand Filtration of Septic Sewage.

Filter No. 100.

Filter No. 100 is 1/20000 of an acre in area, and is constructed of 60 inches in depth of sand of an effective size of 0.26 millimeter. This filter was put into operation Jan. 1, 1898, and at the end of 1905 had been in operation eight years. It has always been flooded with the effluent of Septic Tank A. Owing to the high rate of filtration that has been followed, the upper portions of the filter have become gradually clogged with the organic matter removed from the sewage, and during 1905 the rate of filtration was considerably less than during 1904, this rate being shown on a following table. The filter was raked practically once each week during the year, and it was necessary to allow it to rest several times for short periods, — from January 24 to February 5, from May 2 to 14 and from June 8 to 30. The surface of the filter was dug over 6 inches deep on January 31 and May 6. The table showing the average analysis of its effluent follows: —

Effluent of Filter No. 100.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Length of Time Sewage remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
1904.													
December,	96,300	56	56	–	4.0	2.00	1.4250	.1320	6.15	1.10	.0360	1.74	–
1905.													
January,	115,400	51	60	–	2.0	1.40	2.4600	.2200	8.78	1.27	.0180	1.87	47,800
February,	150,000	55	60	2h.	0.2	0.15	0.7830	.0440	6.10	5.08	.0046	0.35	28,800
March,	200,000	52	57	–	0.1—	0.16	0.3138	.0295	5.61	2.61	.0001	0.33	2,800
April,	192,000	55	58	–	0.1—	0.38	0.7175	.0800	10.37	1.80	.0077	0.49	5,800
May,	118,500	61	58	–	0.2	0.22	0.9000	.0440	7.90	5.46	.0040	0.52	12,000
June,	53,800	62	67	–	0.1—	0.13	0.1060	.0440	9.00	2.77	.0000	0.39	8,000
July,	184,600	74	69	–	0.2	0.15	0.1205	.0305	13.13	1.14	.0002	0.36	13,000
August,	200,000	74	72	–	0.1—	0.21	0.1570	.0430	13.00	2.77	.0000	0.19	8,500
September,	200,000	65	57	–	0.5	0.17	0.3700	.0720	14.65	3.19	.0010	0.48	47,500
October,	200,000	67	60	–	0.5	0.19	0.1060	.0450	10.30	3.58	.0000	0.29	8,000
November,	154,000	58	62	–	0.7	0.19	0.2568	.0523	7.85	3.28	.0001	0.41	18,000
Average,	155,400	61	61	–	0.7	0.45	0.6430	.0697	9.40	2.84	.0060	0.62	18,200

Filter No. 242.

Filter No. 242, constructed of 48 inches in depth of sand of an effective size of 0.41 millimeter, put into operation Feb. 1, 1904, was continued throughout 1905. This filter has always received the effluent of Septic Tank D. The table showing the average analysis of the effluent follows: —

Effluent of Filter No. 242.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
1904.												
December,	51,400	55	57	–	.27	.5500	.0520	10.02	6.38	.0030	.38	275
1905.												
January,	100,000	65	62	–	.20	.3950	.0370	10.32	6.05	.0051	.62	140
February,	78,600	66	62	–	.18	.1720	.0460	7.41	5.07	.0066	.25	1,125
March,	100,000	60	63	–	.14	.1420	.0290	6.20	4.20	.0004	.29	363
April,	100,000	62	62	–	–	.2280	.0260	7.97	4.62	.0072	.23	350
May,	100,000	61	64	–	.15	.0730	.0380	11.14	4.62	.0012	.34	82
June,	20,400	68	–	–	–	–	–	–	–	–	–	–
July,	91,400	72	77	–	.05	.0540	.0180	9.30	2.86	.0004	.80	20
August,	100,000	72	72	–	.02	.0540	.0200	9.62	3.53	.0006	.20	7
September,	100,000	68	66	–	.10	.1320	.0200	12.93	3.19	.0000	.06	110
October,	100,000	65	66	–	.08	.0560	.0420	8.25	3.07	.0002	.16	55
November,	91,400	61	69	–	.11	.1300	.0200	8.40	4.48	.0003	.16	72
Average,	86,100	65	66	–	.13	.1805	.0316	9.23	4.37	.0023	.32	236

Operation of Contact Filters.

During the year, five contact filters were in operation at the station, namely, Filters Nos. 175, 176, 221, 237 and 251.

Filters Nos. 175 and 176.

Filters Nos. 175 and 176, first put into operation June 3, 1901, were continued during 1905. Each filter is 5 feet in depth, and is constructed of pieces of coke of such size that all will pass through a sieve having a 1-inch mesh, 75 per cent. through a ½-inch mesh, and practically none through a sieve with a ¼-inch mesh. Filter No. 175 has always received sewage that has passed through a coke or coal strainer, and Filter No. 176 has received untreated station sewage. Each of these filters was allowed to rest one week in each six. During the year, Filter No. 175 was operated at an average rate of 484,000 gallons per acre daily, and Filter No. 176 at an average rate of 485,000 gallons per acre daily. Filter No. 175, receiving sewage that had passed through a strainer, gave, as usual, the better purification. With the method of operation followed, neither filter lost an appreciable amount of open space during year.

Filter No. 221.

Filter No. 221 is $\frac{1}{5000}$ of an acre in area, and is constructed of 42 inches in depth of broken stone of such a grade that all pieces will pass through a sieve with a 1-inch mesh, 25 per cent. through a ½-inch mesh, but none through a sieve with a ¼-inch mesh. The underdrains of this filter are constructed of 6 inches in depth of cobblestones laid upon brick channels. This filter was put into operation July 7, 1903, and during 1905 was operated at an average rate of 605,000 gallons per acre daily. As during previous years, nitrification was very feeble within this filter, although much of the nitrogen present as free ammonia in the sewage applied was not found in the effluent of the filter, and a very considerable decrease of the organic nitrogen was obtained by the passage of sewage through the filter. The effluent of this filter, however, does not possess the same stable, keeping qualities as the effluent of contact filters constructed of coke, similar to Filters Nos. 175 and 176.

Filter No. 251.

Filter No. 251, $\frac{1}{10000}$ of an acre in area, is constructed of 28 inches in depth of Pennsylvania coke, the pieces being of such size that all will pass through a sieve with a ½-inch mesh, and practically none through a ⅛-inch mesh. This filter was put into operation Aug. 1, 1904, and was continued throughout 1905, being flooded with the effluent of Septic

Tank A. The average rate of filtration during the year was 687,000 gallons per acre daily. Fair nitrification occurred in this filter during the year, and the effluent was of a fairly stable, non-putrefying quality. The average analyses of the effluents of all these filters are shown in the following tables: —

Effluent of Filter No. 175.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December, .	326,700	45	58	4.0	.50	1.3500	.1500	.1320	8.88	3.69	.0880	1.16	-
1905. January, .	630,000	41	63	13.5	.60	1.7713	.3310	.2120	10.16	1.98	.2750	2.16	610,000
February, .	425,000	39	61	3.0	.50	0.2000	.1560	.1180	6.30	1.64	.0360	1.08	670,000
March, . .	490,400	39	61	5.5	.75	0.4550	.1110	.1020	4.93	1.21	.0570	1.05	172,500
April, . .	600,000	46	60	9.0	.57	0.7200	.1710	.1470	7.95	2.11	.0980	1.15	755,000
May, . .	489,000	56	60	5.0	.47	0.4000	.1540	.1110	10.67	2.39	.1110	1.02	220,000
June, . .	145,400	62	-	-	-	-	-	-	-	-	-	-	-
July, . .	581,500	71	72	2.0	.60	0.4050	.1210	.1070	11.00	2.02	.0410	1.12	350,000
August, .	501,000	70	-	3.0	.60	0.4640	.1940	.1220	8.90	2.35	.0044	1.38	260,000
September, .	499,000	64	66	2.0	.60	0.5400	.2000	.0900	13.20	1.91	.0160	1.30	11,000
October, .	620,000	57	58	4.5	.65	0.8900	.2020	.1360	11.28	2.14	.0470	1.31	15,800
November, .	496,000	46	59	6.5	.80	2.6600	.2090	.1460	10.90	1.65	.0800	1.35	563,000
Average,	483,700	53	62	5.3	.60	0.8959	.1817	.1294	9.47	2.10	.0776	1.28	498,400

Effluent of Filter No. 176.

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December, .	342,200	45	58	6.0	.53	1.2000	.2000	.1440	8.11	4.09	.1100	1.53	-
1905. January, .	660,000	41	61	14.0	.60	1.4975	.3110	.2160	9.74	0.71	.2500	1.95	632,500
February, .	420,000	39	55	4.0	.65	0.5700	.1600	.1480	5.59	0.25	.0440	1.13	260,000
March, .	489,600	39	56	7.0	.77	0.7550	.1170	.0790	5.36	0.52	.0515	1.37	133,000
April, . .	660,000	46	56	11.5	.95	3.1400	.3570	.2600	8.24	0.13	.1150	1.79	733,000
May, . .	462,000	56	59	6.5	.66	0.8100	.1360	.1140	9.16	1.02	.0160	1.08	320,000
June, . .	136,200	62	-	-	-	-	-	-	-	-	-	-	-
July, . .	544,600	71	73	13.0	.50	1.6500	.2400	.1700	9.15	0.72	.0400	1.43	440,000
August, .	487,000	70	-	-	-	-	-	-	-	-	-	-	-
September, .	492,000	64	66	4.0	.65	0.5400	.1080	.0900	10.50	0.72	.0030	1.22	660,000
October, .	615,000	57	58	6.0	.57	1.4800	.2360	.1960	9.30	0.75	.0040	1.20	340,000
November, .	508,000	46	57	6.5	.93	3.3000	.2180	.1450	10.50	0.69	.0050	1.44	320,000
Average,	484,700	53	60	7.9	.68	1.4943	.2083	.1562	8.57	0.96	.0639	1.41	426,500

Effluent of Filter No. 221.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.). Sewage.	Temperature (Deg. F.). Effluent.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December,	421,500	45	49	13.0	0.70	2.6500	.3950	.3080	9.07	.07	.0025	3.64	670,000
1905. January,	790,000	41	49	10.0	0.53	1.7900	.2860	.2180	6.60	.97	.0240	2.07	495,000
February,	576,000	39	49	5.0	0.60	1.6500	.2750	.2480	7.80	.03	.0120	1.65	830,000
March,	608,700	39	48	6.0	0.75	0.9875	.2100	1720	6.23	.17	.0095	1.51	440,000
April,	770,000	46	54	15.0	1.10	2.1450	.2790	.2040	9.80	.01	.0085	2.32	410,000
May,	755,700	56	57	15.0	1.50	2.2500	.2475	.1580	7.91	.02	.0000	2.01	635,000
June,	148,100	62	-	-	-	-	-	-	-	-	-	-	-
July,	710,800	71	72	2.0	Dark	0.7000	.4100	.2120	12.35	.02	.0000	2.96	280,000
August,	750,000	70	74	10.0	1.60	1.0800	.1360	-	8.76	.02	.0006	-	-
September,	578,700	64	66	6.0	1.90	1.0800	.1560	.1280	9.92	.20	.0256	1.11	150,000
October,	590,000	57	57	6.0	0.65	1.2800	.2440	.2040	7.05	.17	.0040	1.28	580,000
November,	556,000	46	55	7.5	0.80	1.3600	.2040	.1440	8.60	.23	.0025	1.46	605,000
Average,	604,600	53	53	8.7	1.01	1.5430	.2584	.1996	8.55	.17	.0081	2.00	509,500

Effluent of Filter No. 251.

Date.	Quantity Applied.	Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December,	466,000	56	53	16.0	0.60	2.8000	.3200	.2840	6.80	.34	.0010	2.96	-
1905. January,	800,000	51	57	11.5	0.65	3.2900	.3460	.2840	7.66	.74	.0080	1.85	1,800,000
February,	633,300	55	54	5.0	0.60	2.1500	.2500	.2280	7.90	.52	.0030	1.98	1,120,000
March,	783,300	52	56	7.0	0.72	1.6400	.1640	·1460	6.34	.93	.0050	1.24	330,000
April,	775,000	55	50	10.0	0.72	3.1500	.2850	.1440	10.12	.10	.0100	1.71	280,000
May,	761,000	61	60	6.0	0.43	1.7850	.1810	.1100	6.30	.37	.0059	1.36	340,000
June,	208,700	62	-	-	-	-	-	-	-	-	-	-	-
July,	715,400	73	-	1.8	0.70	1.4700	.1480	.1275	11.70	.81	.0165	1.35	-
August,	735,000	74	-	-	-	-	-	-	-	-	-	-	-
September,	800,000	65	66	8.0	0.76	1.3600	.1400	.1180	10.80	.67	.0020	1.44	300,000
October,	800,000	67	58	6.0	0.70	1.9200	.2280	.2200	8.00	.29	.0040	1.24	370,000
November,	769,000	58	60	10.0	1.10	1.8500	.2320	.1680	5.10	.35	.0012	2.04	360,000
Average,	687,200	61	57	8.1	0.70	2.1415	.2294	.1830	8.07	.51	.0057	1.72	613,000

Double Contact Filtration.

Filter No. 237.

Filter No. 237, 1/20000 of an acre in area, is constructed of clinker varying in size from 3/4 of an inch to 1 3/4 inches in diameter. The clinkers are laid over brick underdrains, and the depth of the filter, including underdrains, is 5 feet 6 inches. The filter receives the effluent of Filter No. 221, and is flooded twice daily. The average rate of filtration followed throughout the year was 738,000 gallons per acre daily, and an effluent was produced of a fairly good quality, high in nitrates and generally non-putrescible. A table showing the average analysis of the effluent of this filter follows: —

Effluent of Filter No. 237.

[Parts per 100,000.]

	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.			Kjeldahl Nitrogen.	Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.			Nitrates.	Nitrites.		
Dec. 1, 1904, to Nov. 30, 1905, inclusive.	738,000	58	55	8.0	.68	.7736	.1807	.1265	.3627	10.50	.92	.0540	1.38	473,000

Intermittent-continuous or Sprinkling Filters.

Filters Nos. 135, 136, 233, 235, 247, 248 and 222.

During 1905, seven intermittent-continuous or sprinkling filters have been in operation. Six of these filters are at the experiment station, and each is 1/20000 of an acre in area; one filter, No. 222, 1/200 of an acre in area, is located at the Andover filtration area. Some of the filters in operation are constructed of smooth and some of rough and porous materials; they are of varying depths, and are operated at differing rates. Filters Nos. 135, 136, 247, 248 and 222 are constructed of broken stone.

Filters Nos. 135 and 136 were first put into operation during 1899, and at the end of 1905 had been in operation six years. Each of these filters is 11 feet 10 inches in depth, and is constructed of broken stone, all of which will pass through a screen with a 1-inch mesh, 40 per cent. through a 1/2-inch mesh and 4 per cent. through a screen with a 1/4-inch mesh. Sewage is distributed over the surface of these filters, as over all other intermittent-continuous filters at the station, by means of auto-

matic tipping basins. During the year, Filter No. 135 was operated at the rate of 1,304,000 gallons per acre daily, and Filter No. 136 at an average rate of 2,082,000 gallons per acre daily. Operating at these rates, nitrification was very active in each filter, as shown by following tables, the average nitrates in Filter No. 135 being 3.41, and in the effluent of Filter No. 136, 2.19 parts per 100,000. While both filters produced an effluent practically non-putrescible, somewhat the better purification was effected by the filter operated at the lower rate. After six years of operation, these filters take sewage as freely as when first started; and, as stated in former reports, the organic matter that accumulates within them for a time finally becomes loosened from the stones and passes out with the effluent. When coming from the filters, this matter has, however, a very different character, owing to the bacterial actions taking place within the filters, from that which it has when it is separated from the sewage and retained within them.

Filters Nos. 247 and 248 are constructed of the same grade of material as in Filters Nos. 135 and 136. They are each shallower than the older filters, however. Put into operation during May, 1904, Filter No. 247 contains 5 feet in depth, and Filter No. 248 8 feet in depth, of broken stone. Each of these filters was operated during the year at an average rate of over 1,300,000 gallons per acre daily, and nitrification was active within them, the better effluent being given by the deeper filter, No. 248. Comparing the effluents of these two filters with that of Filter No. 135, operated at the same rate, but 11 feet 10 inches in depth, it will be noticed that the amount of nitrates present in the effluents increases very steadily with the depth of filtering material. In the effluent of Filter No. 247, 5 feet in depth, the average nitrates were 0.53 parts per 100,000; in the effluent of Filter No. 248, 8 feet in depth, 1.31 parts; and in the effluent of Filter No. 135, 11 feet 10 inches in depth, 3.41 parts per 100,000. A further study of the effluents of the filters, shown in the table, will show that a very considerable improvement occurs as the filters increase in depth.

A fifth filter of broken stone, namely, Filter No. 222, $1/200$ of an acre in area, and located at the Andover filtration area, was first put into operation July 13, 1903, and has always received Andover sewage after the same has passed through the settling basin at the filtration area; that is, it receives sewage of the character of that flowing to the sand beds at this area. This filter contains 8 feet in depth of broken stone, and is constructed as follows: the original cypress tank used was but 6 feet in depth, and in order to obtain a depth of 8 feet, the sides were built up 2 feet with large field stones. For collecting drains, 6-inch Akron drain pipes with open joints are laid across the diameter of the

filter, extending to within two feet of the sides of the filter. Above and around these drain pipes are placed 13 inches of large field stones, some of which are nearly a foot in diameter; on these is placed a layer of 7 inches of small field stone; above this, 54 inches of broken stone, most of the pieces of which are more than 2½ inches in diameter; and on top of this a layer of 22 inches of broken stone of a somewhat smaller grade. During 1905, the average rate of operation of this filter was 1,471,000 gallons per acre daily, and nitrification was fairly active within it; not as active, however, as in Filter No. 248 of the same depth at the experiment station, owing largely to the coarser grade of material of which Filter No. 222 is constructed.

Filters Nos. 233 and 235, constructed of clinker, and first put into operation in the early part of 1904, were operated throughout 1905. Each filter contains 69 inches in depth of material. Filter No. 233 is constructed of pieces of clinker that vary in size from ¾ to 1¾ inches; while Filter No. 235 contains clinker, the pieces of which vary from ¼ of an inch to ¾ of an inch in diameter. The average rate of operation of each filter was about 870,000 gallons per acre daily, and the better effluent was given by the filter of finer material.

Effluent of Filter No. 135.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
1904.													
December, .	833,000	45	48	11.0	.51	0.8350	.2950	.1160	7.77	1.84	.0110	2.60	62,500
1905.													
January, .	1,500,000	41	48	11.5	.48	1.8600	.4450	.1760	6.46	4.78	.0090	3.13	155,300
February, .	1,166,600	39	45	7.0	.35	1.2800	.2800	.1180	4.31	2.76	.0080	2.15	47,500
March, .	1,500,000	39	46	5.0	.47	1.1625	.2900	.1290	5.70	5.46	.0053	1.84	51,500
April, . .	1,495,000	46	47	3.0	.61	0.8300	.1540	.0910	7.75	2.47	.0085	1.14	34,300
May, . .	1,492,600	56	53	4.5	.53	0.6750	.2700	.1000	8.13	2.60	.0100	2.01	56,800
June, . .	403,800	62	-	-	-	-	-	-	-	-	-	-	-
July, . .	1,357,700	71	70	2.0	.48	0.2640	.1640	.0990	11.18	4.11	.0080	1.21	74,000
August, .	1,500,000	70	76	1.0	.35	0.0885	.1280	.0980	8.87	2.65	.0025	1.23	15,000
September, .	1,488,000	64	66	1.5	.45	0.1640	.1330	.0980	10.00	3.82	.0014	1.42	15,000
October, .	1,500,000	57	57	4.5	.48	0.5200	.1940	.1030	10.53	3.45	.0020	1.45	27,000
November, .	1,408,000	46	56	2.5	.45	0.3025	.1500	.0720	7.45	3.57	.0024	1.28	19,000
Average,	1,304,000	53	55	4.9	.47	0.7256	.2275	.1091	8.01	3.41	.0062	1.77	61,000

Effluent of Filter No. 136.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
1904. December, .	1,370,400	45	48	15.0	.49	1.7500	.4400	.1300	8.24	1.37	.0150	3.28	62,500
1905. January, .	2,486,900	41	50	15.5	.70	3.2800	.6100	.2180	7.63	2.33	.0075	4.93	299,800
February, .	1,863,300	39	48	8.0	.45	1.7200	.3900	.1540	4.53	1.66	.0150	2.66	110,000
March, . .	2,415,000	39	47	6.5	.29	1.2875	.3400	.1580	5.80	5.41	.0100	1.87	39,000
April, . .	2,480,000	46	48	3.0	.70	1.0175	.1925	.0810	5.24	1.37	.0210	1.25	22,000
May, . .	2,485,200	56	53	8.5	.70	1.1500	.3550	.1280	8.35	1.88	.0160	2.54	49,800
June, . .	616,900	62	–	–	–	–	–	–	–	–	–	–	–
July, . .	2,177,700	71	71	2.5	.75	0.9300	.2300	.1080	11.43	2.55	.0145	2.45	130,000
August, .	2,261,500	70	–	2.0	.60	0.4800	.1410	.0860	10.15	1.26	.0062	1.07	11,000
September, .	2,325,000	64	66	2.5	.60	0.7100	.1900	.1200	11.08	1.85	.0032	1.96	10,000
October, .	2,291,000	57	57	8.0	.60	0.7300	.2540	.0950	10.25	2.60	.0035	2.13	44,000
November, .	2,208,000	46	55	6.5	.63	1.2750	.2500	.1100	8.05	1.84	.0120	1.78	116,500
Average,	2,082,000	53	54	7.1	.59	1.3027	.3084	.1262	8.25	2.19	.0113	2.36	99,900

Effluent of Filter No. 247.

[Parts per 100,000.]

	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.			Kjeldahl Nitrogen.	Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.			Nitrates.	Nitrites.		
Dec. 1, 1904, to Nov. 30, 1905, inclusive.	1,306,000	53	59	8.4	.83	2.4805	.3861	.1965	.7890	9.00	0.53	.0098	2.45	427,800

Effluent of Filter No. 248.

Dec. 1, 1904, to Nov. 30, 1905, inclusive.	1,305,000	53	54	9.7	.65	2.2436	.3786	.2008	.8293	8.14	1.31	.0134	2.56	236,800

Effluent of Filter No. 222.

Dec. 1, 1904, to Nov. 30, 1905, inclusive.	1,471,000	44	45	3.3	.53	2.5951	.4312	.2576	.8367	6.05	0.59	.0313	2.05	594,300

Effluent of Filter No. 233.

[Parts per 100,000.]

	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.			Kjeldahl Nitrogen.	Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.							
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.			Nitrates.	Nitrites.		
Dec. 1, 1904, to Nov. 30, 1905, inclusive.	874,000	53	60	7.3	.60	1.9049	.3340	.1627	.7293	9.06	1.41	.0136	2.25	267,900

Effluent of Filter No. 235.

Dec. 1, 1904, to Nov. 30, 1905, inclusive.	868,200	53	60	6.4	.47	1.1410	.2734	.1106	.5033	8.33	1.78	.0074	2.01	128,400

Double Filtration.

Filters Nos. 224, 249, 250 and 252.

During the year, four secondary filters, namely, Filters Nos. 224, 249, 250 and 252, were operated for the purpose of studying the re-filtration of the effluents of filters of coarse materials. Filter No. 224 is $\frac{1}{20000}$ of an acre in area, and is constructed of 54 inches in depth of sand of an effective size of 0.27 millimeter. This filter was put into operation Oct. 1, 1903. It receives the effluents of Filters Nos. 135 and 136 after they have passed through a sedimentation basin. The average rate of operation during 1904 was nearly 500,000 gallons per acre daily; during 1905, however, it was more difficult to keep the rate of operation high, owing to the gradual accumulation of stable matter that passed through the primary filters to the upper portion of this secondary filter; and the average rate of operation for 1905 was only 421,000 gallons per acre daily. The surface of this filter was raked 3 inches deep thirty-one times during the year, and dug over 6 inches deep four times.

Filters Nos. 249 and 250, each $\frac{1}{20000}$ of an acre in area, were put into operation May 16, 1904. Each is constructed of 60 inches in depth of sand of an effective size of 0.41 millimeter. Each receives the effluents of Filters Nos. 135 and 136 after passage through a sedimentation basin. Their average rate of operation for the year was approximately 630,000 gallons each. As stated in the last report, these two filters, besides being used as a study on re-filtration, are also intended to give information, if possible, in regard to sand removal; that is to say, it is the intention

never to dig over Filter No. 249 to a greater depth than 3 inches, and when this upper 3 inches of sand becomes so clogged with organic matter as to fail to pass sewage, it is to be removed; on the other hand, Filter No. 250 is to be dug over to a greater depth when necessary, and to be kept in operation as long as possible after digging over the upper 6 inches of sand from time to time.

During 1905, the surface of Filter No. 249 was raked 1 inch deep seventeen times, and it was necessary on February 1 to remove the upper 3 inches of sand. Again, on May 24, 1 inch of sand was removed. The surface of Filter No. 250 was raked 1 inch in depth eleven times and 3 inches in depth twice during the year, and dug over to a depth of 6 inches six times.

Filter No. 252, 1/10000 of an acre in area, is constructed of 36 inches in depth of coke breeze on 6 inches in depth of brick underdrains. It receives the effluents of Filters Nos. 233 and 235 after passage through a sedimentation tank. The filter was put into operation Aug. 4, 1904, and during 1905 its average rate of filtration was 742,000 gallons per acre daily. During the year, it was raked over to a depth of 1, 2 or 3 inches seven times and dug over to a depth of 3 inches three times and 9 inches once. The average analysis of the effluents applied to these filters, together with the average analysis of the effluents of each, are given in following tables:—

Effluent applied to Filters Nos. 224, 249 and 250.

[Parts per 100,000.]

	Temperature.	Appearance.		Ammonia.			Kjeldahl Nitrogen.	Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.			Nitrates.	Nitrites.		
Dec. 1, 1904, to Nov. 30, 1905, inclusive.	55	2.0	.71	1.4663	.1417	.1191	.2562	9.17	1.73	.0275	0.93	535,000

Effluent applied to Filter No. 252.

	Temperature.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.	Kjeldahl Nitrogen.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Dec. 1, 1904, to Nov. 30, 1905, inclusive.	59	2.0	.59	1.5510	.1509	.1062	.3629	8.07	1.67	.0365	1.01	240,300

Effluent of Filter No. 224.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
1904. December,	237,000	48	46	0.1—	.22	.0296	.0868	6.83	0.74	.0002	.51	–
1905. January,	600,000	47	45	0.6	.29	.9200	.0810	8.21	4.83	.0060	.75	8,300
February,	483,300	48	45	0.1	.22	.7000	.0700	6.26	2.90	.0032	.61	2,000
March,	555,600	47	45	0.1	.31	.2255	.0565	5.60	1.87	.0179	.52	600
April,	384,000	49	49	0.2	.37	.3220	.0640	6.67	3.11	.0052	.49	800
May,	348,100	57	56	0.1—	.32	.0113	.0512	6.82	2.90	.0000	.59	4,100
June,	169,200	63	63	0.1—	.25	.0048	.0340	9.80	2.45	.0000	.33	6,500
July,	500,000	71	72	0	.22	.0098	.0336	12.80	3.32	.0004	.38	3,800
August,	600,000	70	70	0.1—	.17	.0020	.0214	12.11	2.36	.0000	.25	1,200
September,	346,200	56	56	0.1	.40	.0040	.0408	12.90	2.35	.0000	.54	984,000
October,	508,000	60	59	0.1—	.27	.0048	.0298	9.40	2.79	.0000	.39	21,500
November,	323,000	57	52	0.1—	.23	.0025	.0231	7.90	2.40	.0002	.26	4,750
Average,	421,200	56	55	0.1—	.26	.1864	.0494	8.78	2.67	.0028	.47	94,300

Effluent of Filter No. 249.

Date.	Quantity Applied.	Sewage.	Effluent.	Turbidity.	Color.	Free.	Total Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1904. December,	397,000	48	47	1.0	.37	0.1100	.1080	7.36	4.36	.0050	1.10	–
1905. January,	769,200	47	45	0.6	.32	1.0800	.0960	8.07	4.29	.0040	0.85	33,500
February,	608,300	48	46	0.1	.27	0.7900	.0700	6.17	3.11	.0034	0.62	3,100
March,	785,200	47	47	0.1	.30	0.1236	.0474	5.25	2.14	.0009	0.42	1,150
April,	768,000	49	48	0.1	.45	0.4428	.0698	9.14	3.06	.0082	0.53	600
May,	578,000	57	58	0.2	.40	0.0473	.0653	7.06	2.10	.0027	0.64	678
June,	200,000	63	63	0.1—	.22	0.0086	.0388	9.25	2.78	.0020	0.36	3,000
July,	723,100	71	71	0	.34	0.0108	.0484	12.65	3.41	.0006	0.51	2,500
August,	800,000	70	70	0.1—	.20	0.0042	.0272	11.92	2.45	.0004	0.32	125
September,	761,500	56	56	0.1—	.30	0.0038	.0332	13.45	2.69	.0000	0.43	66,000
October,	708,000	60	59	0	.27	0.0174	.0210	10.50	2.78	.0002	0.32	825
November,	500,000	57	56	0.1—	.27	0.0103	.0298	7.45	3.03	.0001	0.31	4,350
Average,	633,200	56	56	0.1	.31	0.2207	.0546	9.02	3.02	.0023	0.53	10,530

Effluent of Filter No. 250.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
1904.												
December, .	414,800	48	47	2.0	.37	0.1880	.0960	7.05	4.79	.0030	.90	-
1905.												
January, . .	769,200	47	44	0.6	.33	1.3600	.0950	8.09	4.95	.0054	.73	26,300
February, .	608,300	48	46	0.1	.26	0.6800	.0620	6.18	2.90	.0006	.53	3,100
March, . .	758,500	47	45	0.1	.29	0.1609	.0454	5.32	2.31	.0001	.50	700
April, . .	718,400	49	48	0.1	.30	0.0725	.0528	9.07	3.36	.0066	.41	1,350
May, . .	607,000	57	58	0.2	.32	0.0365	.0670	6.79	1.93	.0006	.49	1,600
June, . .	200,000	63	63	0.1—	.20	0.0116	.0446	9.67	2.87	.0002	.44	4,200
July, . .	723,100	71	71	0.1—	.35	0.0234	.0584	13.29	3.23	.0004	.58	7,700
August, . .	800,000	70	70	0.1—	.20	0.0050	.0320	11.95	2.36	.0004	.30	600
September, .	761,500	56	56	0.1	.30	0.0030	.0338	13.60	2.44	.0000	.43	330,000
October, . .	708,000	60	59	0.1—	.30	0.0060	.0372	9.80	3.32	.0000	.37	50,000
November, .	500,000	57	57	0.1—	.27	0.0341	.0352	7.30	3.11	.0000	.33	3,850
Average, .	630,700	56	55	0.2	.29	0.2151	.0550	9.01	3.13	.0014	.50	39,000

Effluent of Filter No. 252.

[Parts per 100,000.]

	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).		Appearance.		Ammonia.			Kjeldahl Nitrogen.	Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.							
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.			Nitrates.	Nitrites.		
Dec. 1, 1904, to Nov. 30, 1905, inclusive.	742,200	60	57	0.1—	.29	.5998	.0487	-	.0950	8.02	1.97	.0184	.41	10,485

FILTRATION OF WATER.

During 1905, studies upon the purification of water by sand filtration were continued. The special features of this work during the year were the operation of various combinations of filters for the purpose of studying double filtration, the use of coagulants in connection with the filtration of Merrimack River water, and investigations in regard to the value of copper sulphate as an aid in filtration. The work of the Lawrence city filter was also followed.

Lawrence City Filter.

The Lawrence city filter is 2.5 acres in area. It was constructed during 1893, and dividing walls separating it into three sections were built during 1902. The following tables present the average chemical and bacterial analyses of many samples of Merrimack River water collected during the year as it flows upon the filter, and of the effluent of the filter collected at different points upon the supply system.

Chemical Analyses.

Merrimack River.

Intake of the Lawrence City Filter.

[Parts per 100,000.]

1905.	Temperature (Deg. F.).	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.						
		Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
Average,	53	0.1—	.41	.0133	.0240	.0190	.33	.016	.0003	.62	1.3

Effluent of the Lawrence City Filter.

1905.	Temperature (Deg. F.).	Turbidity.	Color.	Free.	Total.	In Solution.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average,	54	0.1—	.47	.0132	.0109	.0096	.36	.038	.0001	.42	1.8

Water from the Outlet of the Distributing Reservoir.

1905.	Temperature (Deg. F.).	Turbidity.	Color.	Free.	Total.	In Solution.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average,	54	0.1—	.39	.0072	.0108	.0095	.36	.040	.0001	.37	1.7

Merrimack River — Concluded.

Water from a Tap at Lawrence City Hall.

[Parts per 100,000.]

1905.	Temperature (Deg. F.).	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.						
		Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
Average, . .	55	0.1—	.37	.0057	.0102	–	.36	.042	.0000	.35	1.7

Water from a Tap at Lawrence Experiment Station.

1905.	Temperature (Deg. F.).	Turbidity.	Color.	Free.	Total.	In Solution.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average, . .	55	0.1	.35	.0042	.0092	–	.36	.042	.0000	.33	1.7

Merrimack River as it flows upon Lawrence City Filter.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	14,200	24	101	100.0
February,	14,800	23	125	100.0
March,	10,300	26	98	100.0
April,	3,600	23	38	100.0
May,	1,900	5	26	100.0
June,	9,600	4	60	100.0
July,	3,900	5	57	100.0
August,	19,500	18	272	100.0
September,	13,500	10	189	100.0
October,	39,800	9	169	100.0
November,	8,700	8	160	100.0
Average,	12,700	–	118	100.0
Total,	–	155	–	–

Effluent of Lawrence City Filter.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
			1 c.c.	**100** c.c.
January,	110	99.2	0.0	83.5
February,	55	99.6	0.0	82.7
March,	55	99.5	0.0	40.7
April,	170	95.3	8.7	8.7
May,	12	99.4	0.0	20.0
June,	9	99.9	0.0	50.0
July,	55	98.6	0.0	40.0
August,	37	99.8	33.3	78.0
September,	44	99.7	10.0	70.0
October,	110	99.7	0.0	100.0
November,	70	99.2	0.0	75.0
Average,	70	99.1	4.7	60.0

Water from the Outlet of the Lawrence Reservoir.

[Average of Bacterial Analyses]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.
January,	70	99.5	0.0	83.5
February,	31	99.8	0.0	69.6
March,	80	99.2	0.0	63.0
April,	70	98.1	0.0	9.5
May,	55	97.1	0.0	20.0
June,	20	99.8	0.0	75.0
July,	55	98.6	0.0	60.0
August,	85	99.6	29.4	64.7
September,	51	99.6	10.0	70.0
October,	85	99.8	0.0	66.7
November,	60	99.3	0.0	87.5
Average,	60	99.1	3.6	60.9

Water from a Tap at Lawrence City Hall.

January,	70	99.5	0.0	87.5
February,	33	99.8	0.0	69.6
March,	55	99.5	0.0	59.3
April,	60	98.2	4.3	4.3
May,	34	98.2	0.0	0.0
June,	23	99.8	0.0	25.0
July,	75	98.1	0.0	60.0
August,	51	99.7	17.6	41.1
September,	53	99.6	0.0	50.0
October,	65	99.8	0.0	55.5
November,	70	99.2	37.5	50.0
Average,	54	99.2	5.4	45.7

Lawrence City Water from a Tap at the Experiment Station.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.
January,	44	99.7	0.0	61.5
February,	200	98.6	17.4	56.5
March,	35	99.7	0.0	51.8
April,	95	97.4	4.2	33.3
May,	20	99.2	0.0	0.0
June,	85	98.9	25.0	75.0
July,	65	98.5	4.2	58.3
August,	33	99.8	7.4	48.1
September,	38	99.7	12.0	60.0
October,	45	99.9	0.0	42.3
November,	36	99.6	4.0	88.0
Average,	65	99.2	6.7	52.3

The Use of Copper Sulphate in Water Filtration.

Five filters were operated during a portion of the year with water to which copper sulphate was added. The results of this investigation have been gathered, and are shown in following tables. The filters used were operated at rates varying from 2,500,000 to 4,300,000 gallons per acre daily. Each of these filters was kept in operation, receiving the sulphate in the applied water, for a period of several months, but generally without increased bacterial efficiency. The time of storage of water after receiving the sulphate and before reaching the surface of the filter varied from about one and one-half hours in the case of Filter No. 216, operating at a rate of 40,000,000 gallons per acre daily, to thirteen and one-half hours in the case of Filter No. 219. The copper sulphate applied varied from more than 1 part in 1,000,000 parts of water to 1 part in 7,000,000 parts of water. None of the filters showed better bacterial efficiency during the periods of sulphate addition than when operated normally without the addition of copper sulphate; in fact, rather poorer results were obtained during the periods of copper sulphate addition. A number of analyses of the applied water and of the effluents of these filters were made during this period for the determination of copper, and the results are given in a following table.

These analyses show that, while a considerable percentage of the copper was removed by the filters, their effluents always contained copper in considerable amounts. Special experiments have shown, moreover, that the copper stored in the sand is given up and passes into the effluent after the addition of copper to the applied water ceases.

Table showing Amount of Copper Sulphate applied to Water, and Time of Storage of Water above Sand, in Filters Nos. 8A, 216, 218, 219 and 220.

Filter No. 8A.

1905.	Actual Volume of Water Filtered Daily.	Copper Sulphate.		Rate (Gallons per Acre Daily).	Storage.	
		Parts per Million.	1 Part in (Parts of Water) —		Hours.	Minutes.
January, ...	10,200	2.35	425,000	2,039,000	11	17
February, . . .	9,200	2.68	369,000	1,846,000	12	31
March, ...	4,400	5.62	178,000	889,000	26	10
April, ...	15,300	1.51	664,000	3,053,000	7	32
May, ...	19,700	1.01	986,000	3,943,000	5	51

Filter No. 216.

August, ...	4,094	1.16	860,000	40,942,000	1	27
September, . . .	4,018	1.13	887,000	40,180,000	1	29
October, ...	4,289	1.16	860,000	42,888,000	1	23

Filter No. 218.

August, ...	252	0.17	6,000,000	2,516,000	11	19
September, . . .	244	0.20	5,057,000	2,436,000	11	43
October, ...	258	0.19	5,347,000	2,578,000	11	36

Filter No. 219.

August, ...	245	0.14	7,132,000	2,451,000	13	24
September, . . .	239	0.18	5,560,000	2,392,000	13	20
October, ...	240	0.20	5,053,000	2,404,000	13	20

Filter No. 220.

August, ...	493	0.18	5,655,000	2,463,000	11	56
September, . . .	510	0.19	5,312,000	2,552,000	10	43
October, ...	500	0.19	5,181,000	2,501,000	10	58

Table showing Comparative Bacterial Results on the Effluents from Filters Nos. 8, 216, 218, 219 and 220, during Periods when Copper Sulphate was and was not mixed with the Applied Water.

Effluent of Filter No. 8.

1905.	Notes.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	100 c.c.
Jan. 1 to May 31,	Copper sulphate applied, 1 part in 1,000,000.	120	91.8	23.2	71.4
June 1 to Nov. 31,	No copper applied, . . .	130	98.5	24.2	79.1

Effluent of Filter No. 216.

1905.	Notes.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	100 c.c.
Jan. 1 to July 31,	No copper applied, . . .	500	88.0	8.2	13.4
Aug. 1 to Oct. 31,	Copper sulphate applied, 1 part in 1,000,000.	500	91.3	24.2	21.7

Effluent of Filter No. 218.

1905.	Notes.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	100 c.c.
Jan. 1 to July 31,	No copper applied, . . .	7	89.1	0.0	26.6
Aug. 1 to Oct. 31,	Copper sulphate applied, 1 part in 5,000,000.	7	94.6	0.0	15.0

Effluent of Filter No. 219.

1905.	Notes.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	100 c.c.
May 1 to July 31,	No copper applied, . . .	22	99.9	18.3	60.3
Aug. 1 to Oct. 31,	Copper sulphate applied, 1 part in 5,000,000.	21	99.9	22.0	80.3

Effluent of Filter No. 220.

1905.	Notes.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	100 c.c.
May 1 to July 31,	No copper applied, . . .	53	98.8	8.5	63.5
Aug. 1 to Oct. 31,	Copper sulphate applied, 1 part in 5,000,000.	53	99.6	17.7	77.3

Copper in Applied Waters, Effluents and Sands of Filters, as determined by Analysis.

Filter No. 216.

Date.	Source of Sample.	Parts per 100,000. Copper.	$CuSO_4.5H_2O$.	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —	Per Cent. of Copper removed.
Aug. 17, . .	Applied water, ...	0.02316	0.09092	1,100,000	0
	Effluent, ...	0.02316	0.09092	1,100,000	0
Oct. 4, . .	Applied water, ...	0.00158	0.00620	16,000,000	–
	Effluent, ...	0.00350	0.01374	7,300,000	–
Dec. 5, . .	Effluent, ...	0.00200	0.00785	13,000,000	–

Copper in Applied Waters, Effluents and Sands of Filters, etc. — Concluded.

Filter No. 218.

Date.	Source of Sample.	Parts per 100,000. Copper.	Parts per 100,000. $CuSO_4.5H_2O$.	Equivalent to 1 Part $CuSO_4.5H_2O$ in (Parts of Water) —	Per Cent. of Copper removed.
Aug. 17,	Applied water,	0.00211	0.00828	12,000,000	–
	Effluent,	0.00100	0.00393	25,000,000	52.6
Oct. 4,	Applied water,	0.00361	0.01417	7,100,000	–
	Effluent,	0.00139	0.00546	18,000,000	61.5
Oct. 31,	Applied water,	0.00417	0.01637	6,100,000	–
	Effluent,	0.00139	0.00546	18,000,000	66.6
Nov. 3,	Sand, top foot,	1.96000	7.69500	13,000	–
	Sand, bottom foot,	0.93000	3.65120	27,000	–
Dec. 5,	Effluent,	0.00240	0.06942	11,000,000	–

Filter No. 219.

Date.	Source of Sample.	Copper.	$CuSO_4.5H_2O$.	Equivalent	Per Cent.
Aug. 17,	Applied water,	0.00263	0.01033	9,600,000	–
	Effluent,	0.00100	0.00393	25,000,000	62.0
Oct. 4,	Applied water,	0.00778	0.03054	3,300,000	–
	Effluent,	0.00167	0.00656	15,000,000	78.5
Oct. 31,	Applied water,	0.00333	0.01307	7,700,000	0
	Effluent,	0.00333	0.01307	7,700,000	0
Nov. 3,	Sand, top foot,	1.29000	5.06450	20,000	–
	Sand, bottom foot,	0.77000	3.02300	33,000	–
Dec. 5,	Effluent,	0.00440	0.01727	5,800,000	–

Filter No. 220.

Date.	Source of Sample.	Copper.	$CuSO_4.5H_2O$.	Equivalent	Per Cent.
Aug. 17,	Applied water,	0.00500	0.01963	5,100,000	–
	Effluent,	0.00158	0.00620	16,100,000	68.4
Oct. 4,	Applied water,	0.00528	0.02073	4,800,000	–
	Effluent,	0.00263	0.01033	9,600,000	50.2
Oct. 31,	Applied water,	0.00333	0.01307	7,700,000	0
	Effluent,	0.00333	0.01307	7,700,000	0
Nov. 3,	Sand, top foot,	0.99000	3.88670	26,000	–
	Sand, bottom foot,	0.86000	3.37640	30,000	–
Dec. 5,	Effluent,	0.00280	0.01099	9,100,000	–

Filter No. 243.

Date.	Source of Sample.	Copper.	$CuSO_4.5H_2O$.	Equivalent	Per Cent.
Oct. 4,	Effluent,	0.00639	0.02509	4,000,000	–

Filter No. 244.

Date.	Source of Sample.	Copper.	$CuSO_4.5H_2O$.	Equivalent	Per Cent.
Oct. 4,	Effluent,	0.00250	0.00982	10,000,000	5.0
Dec. 5,	Canal water,	0.00140	0.00550	18,000,000	–

Filtration with the Use of Sulphate of Alumina as a Coagulant. — Copper Sulphate.

Filter No. 216.

This filter, $\frac{1}{10000}$ of an acre in area, containing about 15 inches of sand of an effective size of 0.60 millimeter, was first put into operation during 1903. The applied water, after admixture of sulphate of alumina, was passed to a settling basin, and then filtered at a high rate. During August, September and October copper sulphate was mixed with the applied water in proportion of about 1 part per million gallons.

The filter was so arranged that the total loss of available head was never more than 48 inches, — much less than is usual with filters of this type. Owing to this small loss of head, it was necessary to wash the filter at more frequent intervals than would have been the case had a greater head been available. It is usual in filters of this class to wash the filter whenever the loss of head reaches a certain amount; that is, whenever the rate decreases below the theoretical rate. With this filter, however, this was not done, the sand being washed at stated periods only, — twice daily. For this reason, while the filter was operated during a portion of each run at a rate of 50,000,000 gallons per acre per day, towards the end of the run this rate decreased to somewhat less than this amount, so that the average rate of operation of the filter was considerably less than the intended rate. The amount of coagulant mixed with the applied water was greater than during the preceding year, enough being added at times to reduce completely the natural alkalinity of the applied water. It is customary under such conditions to add soda or some other alkali to the applied water, in order to allow the complete decomposition of the sulphate of alumina added; but the attempt was made in this case to operate the filter *without* the added alkali, in order to determine the effect of such operation on the bacterial character of the effluent. This effluent became acid on a few occasions, and undecomposed alum was occasionally found in the filtered water. A portion of the effluent was applied throughout the year to a secondary filter, No. 243. Tables showing the work of this filter follow: —

Effluent of Filter No. 216.

[Parts per 100,000.]

1905.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
			Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.			
Average,	41,147,000	50	0	.14	.0121	.0109	.35	.017	.0005	.29	64.0	—0.1

Table showing Quantity of Water filtered and Amount of Coagulant.— Filter No. 216.

1905.	Total Number of Gallons filtered.	Coagulant (Grains per Gallon).	1905.	Total Number of Gallons filtered.	Coagulant (Grains per Gallon).
January,	124,576	1.40	July,	125,294	1.48
February,	116,943	1.39	August,	122,826	1.45
March,	112,629	1.43	September,	104,467	1.40
April,	95,285	1.47	October,	124,374	1.45
May,	110,425	1.30	November,	107,358	1.40
June,	118,187	1.43	Average,	114,760	1.42

Applied Water.— Filter No. 216.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	5,000	24	39	96.0
February,	7,900	23	47	100.0
March,	2,300	22	24	100.0
April,	1,500	19	18	95.0
May,	1,600	26	23	100.0
June,	5,100	24	66	96.0
July,	1,000	14	27	100.0
August,	1,600	25	85	100.0
September,	4,500	19	162	100.0
October,	8,600	24	96	83.3
November,	4,800	20	71	95.0
Average,	4,000	–	60	96.8
Total,	–	240	–	–

Effluent of Filter No. 216.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
			1 c.c.	**100** c.c.
January,	600	88.0	16.7	16.7
February,	2,200	72.2	8.7	17.4
March,	55	97.6	0.0	0.0
April,	325	78.3	15.8	10.5
May,	180	88.8	3.8	3.8
June,	110	97.8	12.5	16.7
July,	65	93.5	0.0	28.6
August,	100	93.8	19.2	38.4
September,	325	92.8	20.0	10.0
October,	1,100	87.2	33.3	16.7
November,	1,900	60.4	35.0	20.0
Average,	650	86.4	15.0	16.3

Table showing Removal of Bacteria by Sedimentation, Filtration and Total Removal. — Filter No. 216.

1905.	Average Number of Bacteria in —			Per Cent. of Bacteria removed by —		
	Canal Water.	Water applied to Filter No. 216.	Effluent of Filter No. 216.	Coagulation and Sedimentation.	The Filter.	The System.
January,	6,600	5,000	600	24.2	88.0	90.9
February,	9,800	7,900	2,200	19.5	72.2	77.6
March,	5,700	2,300	55	59.7	97.6	99.0
April,	2,300	1,500	325	34.8	78.3	85.9
May,	2,600	1,600	180	38.5	88.8	93.1
June,	8,600	5,100	110	40.7	97.8	98.7
July,	3,100	1,000	65	67.8	93.5	97.9
August,	7,600	1,600	100	79.0	93.8	98.7
September,	15,000	4,500	325	70.0	92.8	97.8
October,	25,600	8,600	1,100	66.4	87.2	95.7
November,	7,900	4,800	1,900	39.2	60.4	76.0
Average,	8,600	4,000	650	49.1	86.4	91.9

Double Filtration.

Filter No. 243.

This filter, 1/20000 of an acre in area, was first put into operation early in 1904, and during 1905 contained about 20 inches of sand of an effective size of 0.26 millimeter. It was operated at a theoretical rate of 10,000,000 gallons per acre daily, filtering the effluent of Filter No. 216.

During the year, instead of scraping, the upper 2 inches of sand was washed while stirring with a rake through the teeth of which water was forced in fine jets. The upper 2 inches of sand in the filter was washed in this manner ninety-three times during the year.

Tables showing the results of analysis of the effluent of this filter follow, and show that when Filter No. 216 was demonstrating a bacterial efficiency greater than 80 per cent., the effluent of Filter No. 243 contained small numbers of bacteria, and for months at a time was free from B. coli. The filter produced the most satisfactory appearing effluent of any of the filters in operation, it being always low in color.

Effluent of Filter No. 243.

[Parts per 100,000.]

1905.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
Average,	8,345,000	52	0	.09	.0114	.0100	.35	.018	.0004	.20	66.1	0.4

Effluent of Filter No. 243.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	Per Cent. of Samples containing B. Coli. 100 c.c.
January,	185	69.2	8.3	16.7
February,	425	80.7	8.7	13.0
March,	25	54.5	0.0	0.0
April,	13	96.0	0.0	0.0
May,	8	95.5	0.0	0.0
June,	4	96.4	0.0	0.0
July,	8	87.7	6.2	6.2
August,	20	80.0	11.1	29.6
September,	55	83.1	5.0	10.0
October,	43	96.1	8.0	4.0
November,	240	87.4	4.8	9.5
Average,	95	84.2	4.7	8.1

Filter No. 8A.

Filter No. 8A, $\frac{1}{200}$ of an acre in area, was put into operation during 1893. During 1905, this filter contained about 24 inches in depth of sand of an effective size of 0.23 millimeter. The average rate of operation during the year was 3,350,000 gallons per acre daily. The filter

was scraped fifteen times during the eleven months, and, on April 12, the upper 6 inches of sand was dug over. After scraping, the filter was filled with filtered water from below. Beginning May 17, 1904, and continuing until June 9, 1905, copper sulphate was mixed with the applied water. A discussion of the results obtained from the copper treatment during 1904 is contained in the report of the Board for that year, page 282, and in this report, on pages 395–400, inclusive.

Canal Water (Merrimack River Water).

[Parts per 100,000.]

1905.	Temperature (Deg. F.).	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.			
Average,	51	0.1—	.39	.0117	.0217	.34	.017	.0004	.65	61.0	1.3

Effluent of Filter No. 8A.

[Parts per 100,000.]

1905.	Quantity Applied. — Gallons per Acre. Daily.	Temperature (Deg. F.).	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
			Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.			
Average,	3,349,000	50	0	.34	.0034	.0142	.32	.028	.0004	.54	51.9	1.2

Merrimack River Water (Essex Company's Canal).

[Average of Bacterial Analyses].

1905.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	6,600	24	80	100.0
February,	9,800	23	98	100.0
March,	5,700	27	63	100.0
April,	2,300	24	33	100.0
May,	2,600	26	40	100.0
June,	8,600	24	81	100.0
July,	3,100	16	82	100.0
August,	7,600	27	242	100.0
September,	15,000	20	183	100.0
October,	25,600	26	160	100.0
November,	7,900	25	115	96.0
Average,	8,600	-	107	99.6
Total,	-	262	-	-

Bacteria in Applied Water, and Effluent of Filter No. 8A.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.		Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
	Applied Water.	Effluent.		**1** c.c.	**100** c.c.
January,	1,700	150	91.2	41.7	100.0
February,	7,800	190	97.6	23.0	61.5
March,	400	70	82.5	28.6	71.5
April,	1,300	90	93.1	14.3	57.2
May,	1,500	80	94.7	8.3	66.7
June,	8,600	185	97.1	12.5	62.5
July,	3,100	35	98.9	22.2	77.8
August,	7,600	110	98.7	25.0	66.7
September,	15,000	185	98.9	36.3	91.0
October,	25,600	110	99.6	7.7	84.7
November,	7,900	160	97.7	41.7	91.7
Average,	7,318	120	95.5	23.8	75.6

Filters Nos. 218, 219 and 220.

These 3 filters were started in July, 1903, for the purpose of studying the chemical and bacterial quality of effluents resulting from filtering waters of three different degrees of pollution. Their work, during 1903 and 1904, is discussed in the reports for those years. During 1905, besides being used for the purpose stated, they were also used in the copper sulphate investigation, and the results obtained from them along this line are discussed on pages 395–400, inclusive.

Filters Nos. 218 and 219 are $\frac{1}{10000}$ of an acre in area, and Filter No. 20 is $\frac{1}{5000}$ of an acre in area. During the year they contained 42, 39 and 44 inches in depth of sand, respectively, of an effective size of 0.20 millimeter. Filter No. 218 has always received the Lawrence filtered water taken from the distribution main at the experiment station, and its rate of operation during 1905 was 2,500,000 gallons per acre daily. The filter was scraped six times during the year, three of the scrapings in January and one in February being necessary by reason of the fact that the applied water contained more iron in suspension during those months than during the remainder of the year.

Filter No. 219 was operated during a large part of the year with Merrimack River water, to which $\frac{1}{2}$ of 1 per cent. by volume of strained sewage was added. From May 1 to July 31, the rate of operation was

5,000,000 gallons per acre daily, and from August 1 to November 30, inclusive, 2,500,000 gallons per acre daily. The filter was scraped ten times during the year.

Filter No. 220 received Merrimack River water throughout a large part of the year. It was scraped four times. During August, September and October copper sulphate was added with the water applied to each one of these filters, as previously stated.

Tables showing the chemical and bacterial analyses of the effluents of these filters follow. The small numbers of bacteria in the effluent of Filter No. 218 are noteworthy.

Effluent of Filter No. 218.

[Parts per 100,000.]

1905.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
Average,	2,477,000	55	0	.26	.0010	.0077	.35	.046	.0000	.30	66.9	1.8

Effluent of Filter No. 218.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	Per Cent. of Samples containing B. Coli. 100 c.c.
January,	3	92.9	0.0	30.0
February,	9	95.9	0.0	27.2
March,	4	88.6	0.0	36.0
April,	9	90.5	0.0	4.2
May,	7	69.6	0.0	0.0
June,	8	98.4	0.0	38.4
July,	10	88.9	0.0	37.5
August,	9	95.9	0.0	14.3
September,	5	95.5	0.0	30.8
October,	6	92.5	0.0	0.0
November,	5	91.7	0.0	0.0
Average,	7	90.9	0.0	19.8

Applied Water. — Filter No. 219.

[Parts per 100,000.]

1905.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
			Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.			
Average,	-	59	0.1—	.42	.0196	.0238	.37	.020	.0003	.59	48.5	1.2

Effluent of Filter No. 219.

Average,	3,642,000	60	0	.31	.0035	.0115	.37	.028	.0003	.44	19.6	1.2

Applied Water. — Filter No. 219.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
May,	20,200	13	339	100.0
June,	12,800	7	198	100.0
July,	17,800	9	931	89.0
August,	8,800	14	251	100.0
September,	44,700	11	257	100.0
October,	46,400	13	595	100.0
November,	28,200	12	791	100.0
Average,	25,600	-	480	98.4
Total,	-	79	-	-

Effluent of Filter No. 219.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.
May,	18	99.9	7.2	57.1
June,	16	99.9	14.3	57.2
July,	31	99.8	33.3	66.6
August,	9	99.9	42.8	71.5
September,	14	99.9	7.7	84.7
October,	39	99.9	15.4	84.7
November,	190	99.3	41.6	100.0
Average,	45	99.8	23.2	74.5

Effluent of Filter No. 220.

[Parts per 100,000.]

1905.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
			Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.			
Average,	2,395,000	61	0	.31	.0031	.0119	.34	.019	.0008	.48	14.5	1.2

Effluent of Filter No. 220.

[Average of Bacterial Analyses.]

1905.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
			1 c.c.	**100** c.c.
April,	55	42.1	37.5	75.0
May,	34	98.7	7.2	42.8
June,	95	98.6	18.2	72.8
July,	29	99.1	0.0	75.0
August,	21	99.5	28.6	71.5
September,	19	99.7	7.7	77.0
October,	120	99.6	16.7	83.4
November,	100	98.5	50.0	100.0
Average,	60	92.0	20.7	74.7

Filter No. 244.

This filter, containing 60 inches of sand of an effective size of 0.23 millimeter, was first put into operation Feb. 16, 1904. It was operated with canal water at a theoretical rate of 2,500,000 gallons per acre daily until February 28. Beginning March 1 and continuing until May 4, the effluent of Filter No. 220 was applied at the rate of 10,000,000 gallons per acre daily, the filter being operated as a secondary filter. The period of preliminary operation with canal water, that is, the period of biological construction, had not been continued long enough, however, to coat the sand grains with the bacteria and organic matter necessary for a well-ripened filter, as was evidenced by the fact that its effluent contained more bacteria than did the applied water. On May 5, therefore, canal water was again applied at a rate of 5,000,000 gallons per acre

daily, this being continued until June 15, at which time the bacterial analyses showed that the filter had become well ripened. The effluent of Filter No. 220 was again applied, and the filter was operated at a rate of 10,000,000 gallons per acre daily until December 22. From Dec. 23 until March 2, 1905, owing to low water in the Essex Company's canal, Filter No. 220 was not operated; and during this period Filter No. 244 was operated with canal water at a rate of 10,000,000 gallons per acre daily. From March 3 until April 30, filtered water from the Lawrence service mains was applied at a rate of 10,000,000 gallons per acre daily. Beginning May 1 again and continuing throughout the year, the filter was operated with the effluent from Filter No. 220. From December 23 to March 2, while operating with canal water, the filter was scraped five times; during March and April, while operating with city water, the filter was scraped once; and from May 1 until the end of the year, that is while operating with the effluent from Filter No. 220, it was scraped only three times.

Effluent of Filter No. 244.

[Parts per 100,000.]

1905.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature (Deg. F.).	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Total Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Hardness.
Average,	9,167,000	53	0	.33	.0054	.0125	.36	.023	.0004	.47	36.3	1.5

Effluent of Filter No. 244.— Average of Bacterial Analyses during Periods when operated with Canal Water.

Date.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli. 1 c.c.	Per Cent. of Samples containing B. Coli. 100 c.c.
1904.				
February 16 to February 28,	10,600	-	-	-
May 5 to May 31,	350	87.0	-	-
June 1 to June 14,	220	98.5	-	-
1905.				
January,	950	81.0	70.0	80.0
February,	900	90.8	75.0	66.7
Average,	2,600	89.3	72.5	73.4

Effluent of Filter No. 244. — Average of Bacterial Analyses during Periods when operated with Effluent of Filter No. 220.

Date.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.
1904.				
March,	4,600	-	-	-
April,	500	-	-	-
June 15 to 30,	475	-	-	-
July,	425	-	-	-
August,	42	-	30.8	0.0
September,	180	33.5	12.5	50.0
October,	48	12.7	0.0	0.0
November,	49	34.7	10.0	30.0
December,	170	-	0.0	20.0
1905.				
May,	38	81.0	0.0	28.8
June,	140	26.3	0.0	90.0
July,	85	22.7	0.0	62.5
August,	160	11.1	8.3	66.7
September,	65	50.0	0.0	38.4
October,	41	65.8	8.3	75.0
November,	60	40.0	8.3	91.7
Average, June to December, 1904,	200	-	10.7	20.0
Average, May to November, 1905,	85	42.4	3.6	64.7

Table showing Percentage Removal of Bacteria by Double Filtration Systems.

1905.	Lawrence City Filter and Filter No. 218.	Filter No. 216 and Filter No. 243.	Filter No. 220 and Filter No. 244.
January,	99.9	97.2	-
February,	99.9	95.7	-
March,	99.9	99.6	-
April,	99.7	99.4	-
May,	99.6	99.7	98.5
June,	99.9	99.9	98.4
July,	99.7	99.8	97.3
August,	99.9	99.7	97.9
September,	99.9	99.6	99.6
October,	99.9	99.8	99.8
November,	99.9	96.6	99.2
Average,	99.8	98.8	98.7

EXAMINATION OF SEWER OUTLETS

AND OF

TIDAL WATERS AND FLATS FROM WHICH SHELLFISH ARE TAKEN FOR FOOD.

By X. H. GOODNOUGH, *Chief Engineer.*

EXAMINATION OF SEWER OUTLETS AND OF TIDAL WATERS AND FLATS FROM WHICH SHELLFISH ARE TAKEN FOR FOOD.

By X. H. GOODNOUGH, *Chief Engineer.*

The work done upon the examination of sewer outlets and the investigation of the condition of shellfish in the flats and waters of the Commonwealth during the year 1905 has been confined to Boston harbor. The effect of the discharge of sewage from each of the principal sewer outlets into the harbor has been examined and numerous chemical and bacterial analyses have been made of water both from the neighborhood of the sewer outlets and from other parts of the harbor. The shores of the harbor and of the islands therein and the flats exposed at low water have also been carefully inspected, and numerous samples of shellfish (clams) have been collected and analyzed. The results of the investigation are presented in the following report.

The examinations of the sewer outlets and the general condition of the harbor have been made with the assistance of Mr. Laurence Bradford, who has had many years' experience in this work. The samples of shellfish and of the harbor waters generally were collected by Mr. Henry E. Mead.

The principal sewer outlet in Boston harbor is at Moon Island, where the sewage of the Boston main drainage works has been discharged since 1884. At the present time about 100,000,000 gallons of sewage are ordinarily discharged daily at this outlet. The sewage is discharged only during the second and third hours of the outgoing tide, and reservoirs have been provided on Moon Island to store the flow of sewage at other times. At the present time, consequently, about 50,000,000 gallons of sewage are discharged into the harbor at Moon Island on each tide, the discharge lasting about two hours, so that the rate of discharge is approximately 25,000,000 gallons per hour.

The sewage from the city sewers on its way to Moon Island passes first through large deposit sewers or tanks for the removal of heavier matters,

then through a tunnel about a mile and a quarter in length under Dorchester bay, and is subsequently stored in the reservoirs for a period of several hours, and in consequence the sewage is much decomposed when it reaches the outlet.

Observations of the area covered by the discharge of sewage from Moon Island show that the sewage passes out of the harbor chiefly around the southerly end of Long Island, between Long and Rainsford islands; but a portion passes north of Long Island, at least at times, and a portion also south of Rainsford Island. The outlines of the area affected by sewage are quite well defined on calm days by the greasy film or sleek upon the surface of the water.

The next main sewer outlet of importance is that at Deer Island, where the sewage of the North Metropolitan Sewerage District has been discharged continuously into the harbor at all stages of the tide since 1895. There are no reservoirs or deposit sewers along the line of the main sewer leading to this outlet, and the sewage is considerably fresher than that discharged at Moon Island. The quantity of sewage discharged at Deer Island at the present time amounts to about half that discharged at Moon Island, or about 50,000,000 gallons per day; and, as the discharge is continuous, the rate of discharge is consequently approximately 2,000,000 gallons per hour, or a little less than one-twelfth the rate of discharge at Moon Island when the reservoirs are emptied there. The outlet is located at the end of a long sand bar exposed only at low water. On the outgoing tide the sewage at Deer Island flows rapidly to sea in a narrow field, and is rarely traceable at any considerable distance from the outlet except in calm weather, when it can be noted in the water for perhaps a mile under favorable conditions. As the tide turns, the flow of sewage turns southerly and then westerly, and after the water has risen over the bar the flow is established generally in a narrow field in the direction of Apple Island; and toward high water the sleek can be noticed for a mile from the outlet on calm days, lying between the main ship channel and Deer Island. On the turn of the tide the sewage quickly passes to sea, and evidences of it disappear from this area.

A third main sewer outlet, known as the Peddock's Island outlet, was completed last year, and is the place of disposal of the sewage of the South Metropolitan District. At this outlet the sewage is at present discharged alternately at two points, one located about 1 mile due north of Nut Island, and the other 1,500 feet farther east, both outlets being a short distance northwest of the southerly end of Peddock's Island. At Peddock's Island, as at Deer Island, the sewage is discharged continuously without storage at any point; and during the past year about

20,000,000 gallons of sewage per day have been discharged at all stages of the tide, the rate of flow here being a little over 800,000 gallons per hour, or about two-fifths the rate at which sewage is discharged at Deer Island. The observations during the past year show that the presence of the sewage in the water can ordinarily be detected only in the immediate neighborhood of the outlet.

In addition to the sewage discharged at these main outlets, a large quantity of sewage overflows at times of rain from the combined sewer systems in Boston, Cambridge, Somerville and Chelsea, and large quantities of sewage are discharged at such times into the Charles and Mystic rivers and into the upper harbor, and a small quantity into the estuary of the Neponset River. In addition to this sewage, a considerable quantity of sewage is discharged directly into the harbor or its tributaries from a few sewers not connected with the metropolitan systems, chiefly in Chelsea. These sewers are described in the annual report of the State Board of Health for the year 1902, pages 294, 295 and 309. A very large proportion of the sewage of the city of Chelsea (population in 1905, 37,289) is discharged into the tidal waters about that city, at the head of Boston harbor, and causes very serious local nuisances, besides polluting the harbor. Connections have already been made by which the sewage from the principal sewers in this district could be discharged into the metropolitan sewerage system; but these connections have been shut off, on account, apparently, of the neglect of the Chelsea authorities to maintain their sewers in proper condition. Besides the sewage from these outlets and from the storm overflows of combined systems, the harbor receives also a considerable quantity of direct pollution by sewage from buildings and wharves along its shores and from vessels, and a small quantity of sewage is also discharged into the harbor from public institutions on the islands. The flats about Spectacle Island, on which a garbage disposal plant and a rendering establishment are located, are very foul.

Visible Effects of the Discharge of Sewage into Boston Harbor.

The sewage from the Moon Island outlet greatly discolors the water for a distance of half a mile to a mile from the outlet; but it is very difficult to trace it under favorable conditions for more than two miles, even by careful inspection.

The sewer outlet at Moon Island is located at the northwesterly corner of the island, and the sewage is discharged at the level of the water. A sea wall extends for about 1,500 feet southwest from the outlet, and when the sewage is discharged it eddies against this wall throughout

its length, and deposits of organic matter take place in the shallow water here during the summer season. These deposits are usually removed by the heavy easterly storms of the fall and winter, but they reappear again in the summer; and the existence of these deposits, combined with the effect of the eddy, is probably responsible in part for the constant presence of a slight excess of organic matter in the waters in this region above those of other parts of the harbor. On the incoming tide the polluted water in the neighborhood of the wall passes up along the south shore of Moon Island toward Quincy bay. Under some conditions in summer, especially on the incoming tide, a small quantity of sewage is said to work up along the northerly side of the island and deposits form at times near the shore on the northerly side of the outlet. These deposits do not appear to be permanent, and are removed by the waves and currents from time to time. With the exception of the deposits noted in the neighborhood of the wall, no other noticeable deposits appear to take place in the neighborhood of this outlet.

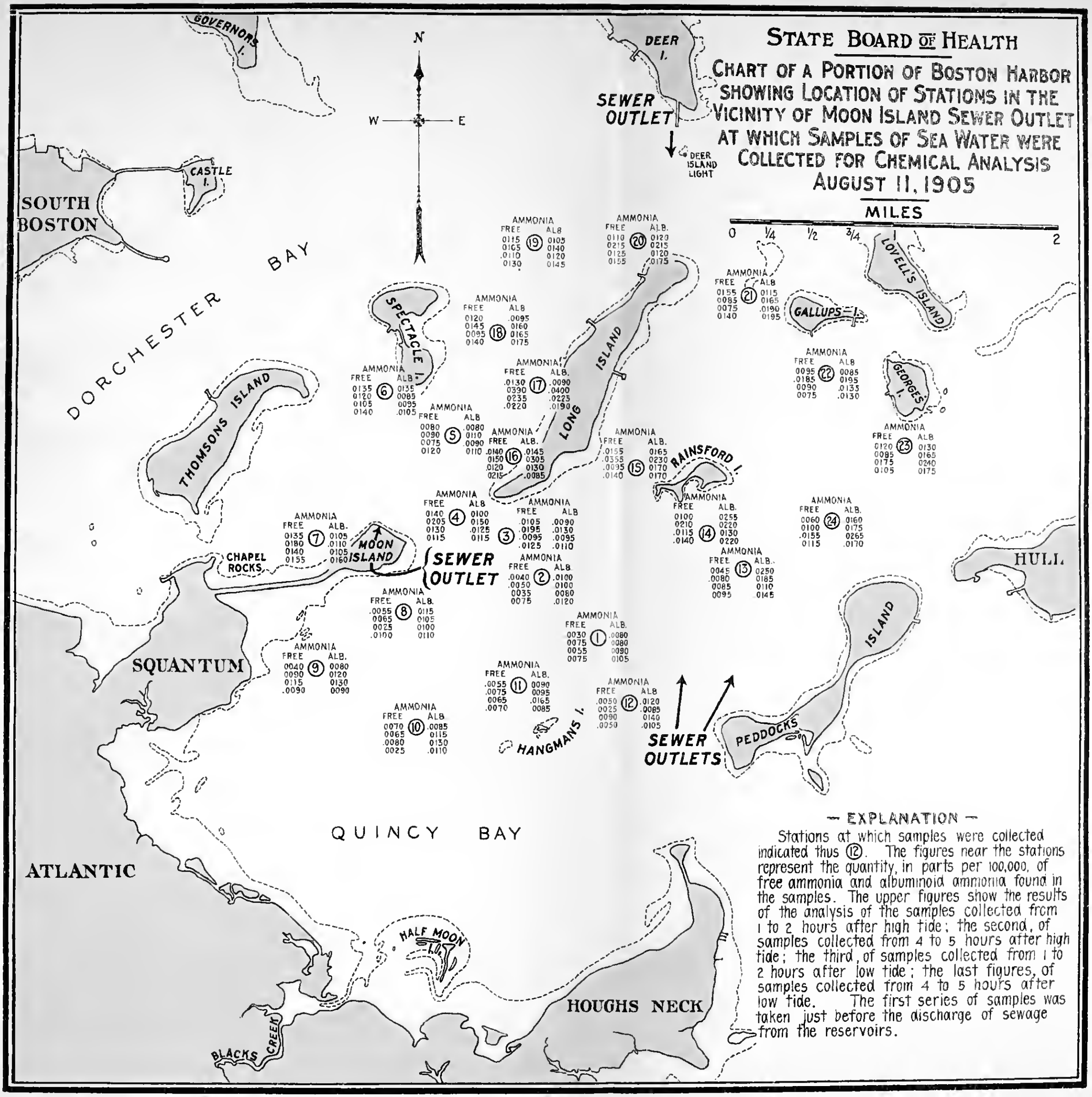
Sewage from the Deer Island outlet discolors the water for a distance of about half a mile from the outlet under favorable conditions, and is traceable for a mile to a mile and a quarter under such conditions; but at these distances the indications of sewage are so slight that they are difficult to trace, and can only be detected in places. The sewage from the Peddock's Island outlet can be traced under the most favorable conditions for less than a mile from the outlet.

The odor from the Moon Island outlet is offensive for a distance of about half a mile from the outlet, and is noticeable at times at greater distances. At Deer Island an odor is rarely noticeable for a distance of more than a quarter of a mile, while at Peddock's Island an odor is observable under present conditions only immediately about the outlet.

Chemical Examination of the Harbor Water about the Moon Island and Deer Island Sewer Outlets.

In order to determine more definitely the area in the harbor materially affected by the discharge of sewage at the Moon Island and Deer Island sewer outlets, samples of sea water were collected for chemical analysis at 24 stations in the vicinity of Moon Island and at 14 stations near Deer Island in August and September, and the results are presented in tables and a map appended hereto. All of the samples were collected at the surface of the water, which at times was affected considerably by the wind.

The first series at Moon Island was collected just before the discharge of sewage from the reservoirs, and consequently about ten hours after


STATE BOARD OF HEALTH
CHART OF A PORTION OF BOSTON HARBOR SHOWING LOCATION OF STATIONS IN THE VICINITY OF MOON ISLAND SEWER OUTLET AT WHICH SAMPLES OF SEA WATER WERE COLLECTED FOR CHEMICAL ANALYSIS AUGUST 11, 1905
MILES
0 1/4 1/2 3/4 1 2
N
W
E
GOVERNORS I.
DEER I.
SEWER OUTLET
DEER ISLAND LIGHT
CASTLE I.
SOUTH BOSTON
DORCHESTER BAY
SPECTACLE
THOMSONS ISLAND
LONG ISLAND
LOVELL'S ISLAND
GALLUPS I.
GEORGES I.
RAINSFORD I.
MOON ISLAND
CHAPEL ROCKS
SEWER OUTLET
HULL
SQUANTUM
HANGMANS I.
SEWER OUTLETS
PEDDOCKS ISLAND
QUINCY BAY
ATLANTIC
HALF MOON I.
HOUGHS NECK
BLACKS CREEK
AMMONIA FREE ALB 19 0115 0105 0105 0140 .0110 0120 0130 0145
AMMONIA FREE ALB. 20 0110 0120 0215 0215 0125 0120 0155 .0175
AMMONIA FREE ALB 21 0155 0115 0085 0165 0075 .0190 0140 0195
AMMONIA FREE ALB 18 0120 .0095 0145 0160 0095 0165 0140 0175
AMMONIA FREE ALB 6 0135 0135 0120 0085 0105 0095 0140 .0105
AMMONIA FREE ALB. 17 .0130 .0090 0390 .0400 0235 .0225 .0220 .0190
AMMONIA FREE ALB 22 0095 0085 .0185 0195 0090 .0133 0075 .0130
AMMONIA FREE ALB 5 0080 .0080 0090 0110 0075 .0090 0120 0110
AMMONIA FREE ALB. 16 .0140 .0145 0150 0305 .0120 0130 0215 .0085
AMMONIA FREE ALB. 15 .0155 0165 .0355 0230 .0095 0170 .0140 0170
AMMONIA FREE ALB 23 0120 0130 0085 0165 0175 0240 0105 0175
AMMONIA FREE ALB 4 0140 0100 0205 0150 0130 .0125 0115 0115
AMMONIA FREE ALB 3 .0105 .0090 .0195 .0130 .0095 .0095 .0125 .0110
AMMONIA FREE ALB. 14 0100 0255 0210 0220 .0115 0130 .0140 0220
AMMONIA FREE ALB. 24 0060 0160 0100 0175 .0155 0265 0115 .0170
AMMONIA FREE ALB. 7 0135 0105 0180 .0110 0140 0105 0155 0160
AMMONIA FREE ALB 2 .0040 .0100 .0050 0100 0035 0080 0075 .0120
AMMONIA FREE ALB. 13 0045 0250 .0080 0185 0085 0110 0095 .0145
AMMONIA FREE ALB. 8 .0055 0115 0065 0105 0025 0100 .0100 0110
AMMONIA FREE ALB. 1 0030 .0080 0075 0080 0055 0090 0075 0105
AMMONIA FREE ALB. 9 0040 0080 0090 0120 0115 0130 .0090 0090
AMMONIA FREE ALB. 11 .0055 0090 .0075 0095 0065 .0165 .0070 0085
AMMONIA FREE ALB 12 .0050 .0120 0025 .0085 0090 0140 .0050 .0105
AMMONIA FREE ALB. 10 0070 .0085 0065 0115 .0080 0130 0025 .0110
— EXPLANATION —
Stations at which samples were collected indicated thus 12. The figures near the stations represent the quantity, in parts per 100,000, of free ammonia and albuminoid ammonia found in the samples. The upper figures show the results of the analysis of the samples collected from 1 to 2 hours after high tide; the second, of samples collected from 4 to 5 hours after high tide; the third, of samples collected from 1 to 2 hours after low tide; the last figures, of samples collected from 4 to 5 hours after low tide. The first series of samples was taken just before the discharge of sewage from the reservoirs.

the previous discharge had ceased. The results show that the free ammonia at the stations within the area which have usually, by observation, appeared to be affected by the sewage from this outlet, was considerably higher than at the stations outside, although at the times these samples were collected there were no visible evidences of sewage in the water except in the neighborhood of the outlet and along the sea wall. It should be stated here that in all cases a persistently high free ammonia was found in a station close to Spectacle Island, the presence of which is apparently due to local pollution from the garbage disposal plant and rendering works on this island.

A second series of samples, collected between four and five hours after high tide, and consequently from one to two hours after the discharge of sewage had ceased, gave results similar to those just described, in that approximately the same area was affected which was found to be affected before the discharge had taken place; but in the latter series of samples both the free and albuminoid ammonia were decidedly higher at practically all of the stations affected than at the previous time.

A third series of samples, collected from one to two hours after low water, and consequently from four to five hours after the last discharge of sewage had ceased, shows a similar result. A slight effect of the sewage can be detected from these analyses on both sides of Moon Island and along both sides of Long Island to the edge of the main ship channel. It is also noticeable in the area around Rainsford, Gallup's and George's islands. An area having a slightly greater amount of free ammonia is also noticeable about Hangman's Island in Quincy bay. This may be due to the discharge of sewage from the Peddock's Island sewer, which may go in this direction for a short time after low water.

A fourth series of samples, collected from three to four hours after low water, or from six to seven hours after the previous discharge of sewage had ceased, showed approximately the same results as were shown by the first series of samples already described.

The results of this examination show that the sea water in the area over which sewage flows twice daily from the outlet at Moon Island contained constantly at this time a slightly greater quantity of organic matter than is found in the adjacent harbor waters not reached by the sewage from this outlet.

In the area toward which sewage flows on the incoming tide from the Deer Island outlet, in the portion of the harbor north of a line drawn from Deer Island Light to Fort Independence, four samples of water were collected at regular intervals at 14 stations, one sample being collected about two hours after low tide, a second about five hours after low tide, a third about two hours after high tide and a fourth about

five hours after high tide. The samples collected two hours and five hours, respectively, after low tide, represent the conditions existing when sewage from the Deer Island outlet is flowing toward the section of the harbor examined. The samples collected about two hours and five hours, respectively, after high tide, represent the condition of the water in this area when the sewage from Deer Island is flowing out to sea.

An examination of the results of the analyses shows, in general, that the quantity of free ammonia in the water of this area was greater about two hours after low tide than at any other time, while the least quantity was found in the samples collected five hours after low water. The differences in the quantities of free ammonia present in the water in different parts of the area were not large. The greatest quantities were present in the samples collected two hours after low water along the southerly edge of the area, *i.e.*, along a line drawn from the sewer outlet toward the southerly end of Governor's Island. North of this line the quantities were less, as the following table shows: —

Table showing Quantities of Free and Albuminoid Ammonia in Waters of Boston Harbor North of the Main Ship Channel. (1905.)

[Averages of results at stations in lines parallel with the ship channel. See map.]

Stations.	Two Hours after Low Water.		Five Hours after Low Water.		Two Hours after High Water.		Five Hours after High Water.	
	Free.	Albuminoid.	Free.	Albuminoid.	Free.	Albuminoid.	Free.	Albuminoid.
4, 5, 14,	.0177	.0118	.0043	.0103	.0095	.0093	.0128	.0107
3, 6, 13,	.0130	.0105	.0072	.0098	.0102	.0100	.0107	.0095
2, 7, 8, 9,	.0136	.0109	.0072	.0102	.0092	.0100	.0115	.0100
Average,	.0148	.0111	.0062	.0101	.0096	.0098	.0117	.0101

Grouping those stations at approximately equal distances from the outlet, it appears that at two hours after low water the quantity of free ammonia in the water was less at stations 10, 11 and 12, farthest from the outlet, than at the stations nearer the outlet; while at five hours after low water the opposite was true, *i.e.*, the quantity of free ammonia was highest at stations 10, 11 and 12, farthest from the outlet. The quantity of free ammonia present in the water two hours after high tide was also greatest at the stations farthest from the outlet, — a condition which is probably due in part at least to pollution coming down the harbor from points above. The results of these groupings are shown by the following table: —

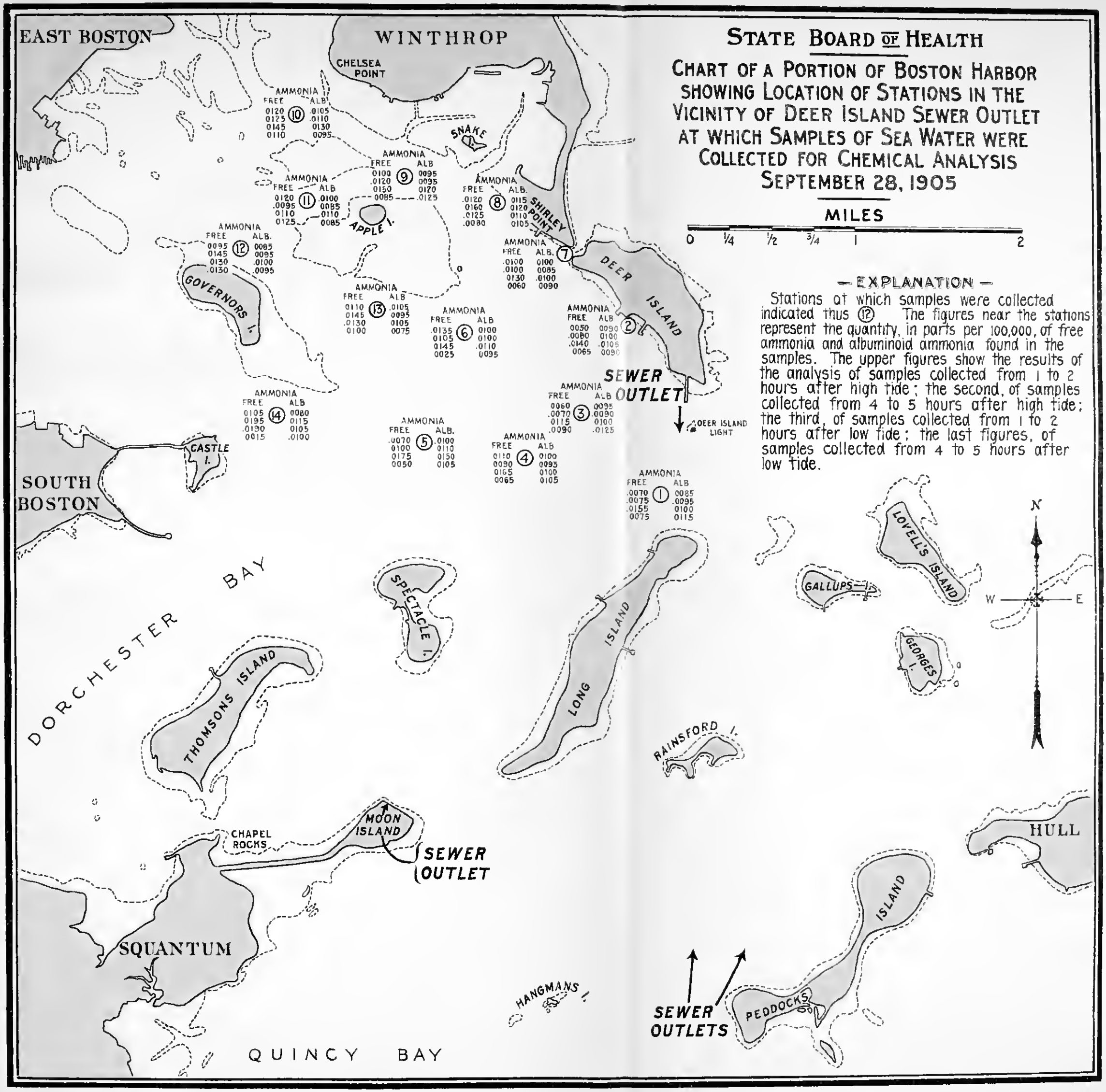

STATE BOARD OF HEALTH
CHART OF A PORTION OF BOSTON HARBOR SHOWING LOCATION OF STATIONS IN THE VICINITY OF DEER ISLAND SEWER OUTLET AT WHICH SAMPLES OF SEA WATER WERE COLLECTED FOR CHEMICAL ANALYSIS SEPTEMBER 28, 1905
MILES
0 1/4 1/2 3/4 1 2
— EXPLANATION —
Stations at which samples were collected indicated thus (12) The figures near the stations represent the quantity, in parts per 100,000, of free ammonia and albuminoid ammonia found in the samples. The upper figures show the results of the analysis of samples collected from 1 to 2 hours after high tide; the second, of samples collected from 4 to 5 hours after high tide; the third, of samples collected from 1 to 2 hours after low tide; the last figures, of samples collected from 4 to 5 hours after low tide.
EAST BOSTON
WINTHROP
CHELSEA POINT
SNAKE I.
APPLE I.
SHIRLEY POINT
DEER ISLAND
GOVERNORS I.
CASTLE I.
SOUTH BOSTON
SEWER OUTLET
DEER ISLAND LIGHT
AMMONIA FREE ALB 0120 0125 0145 0110 (10) .0105 .0110 0130 0095
AMMONIA FREE ALB 0100 .0120 0150 0085 (9) 0095 0095 0120 .0125
AMMONIA FREE ALB 0120 .0095 0110 0125 (11) .0100 0085 .0110 0085
AMMONIA FREE ALB. .0120 0160 .0125 .0080 (8) 0115 0120 0110 0105
AMMONIA FREE ALB. 0095 0145 0130 .0130 (12) 0085 0095 .0100 .0095
AMMONIA FREE ALB. .0100 .0100 0130 0060 (7) 0100 0085 .0100 0090
AMMONIA FREE ALB 0110 0145 .0130 0100 (13) .0105 0095 0105 0075
AMMONIA FREE ALB .0135 0105 0145 0025 (6) 0100 0100 .0110 0095
AMMONIA FREE ALB 0050 .0080 .0140 0065 (2) 0090 0100 .0105 0090
AMMONIA FREE ALB 0060 .0070 0115 .0090 (3) 0095 .0090 0100 .0125
AMMONIA FREE ALB 0105 0195 .0190 0015 (14) 0080 0115 0105 .0100
AMMONIA FREE ALB. .0070 0100 0175 0050 (5) .0100 0110 0150 0105
AMMONIA FREE ALB 0110 0090 0165 0065 (4) 0100 0095 0100 0105
AMMONIA FREE ALB .0070 .0075 .0155 0075 (1) 0085 .0095 0100 0115
DORCHESTER BAY
SPECTACLE I.
LONG ISLAND
LOVELL'S ISLAND
GALLUPS I.
GEORGES I.
N
W
E
THOMSONS ISLAND
RAINSFORD I.
MOON ISLAND
CHAPEL ROCKS
SEWER OUTLET
HULL
SQUANTUM
ISLAND
PEDDOCKS
HANGMANS I.
SEWER OUTLETS
QUINCY BAY

Table showing Quantities of Free and Albuminoid Ammonia in Waters of Boston Harbor North of the Main Ship Channel. (1905.)

[Averages of results at stations at approximately equal distances from the Deer Island sewer outlet. See map.]

Stations.	Two Hours after Low Water.		Five Hours after Low Water.		Two Hours after High Water.		Five Hours after High Water.	
	Free.	Albuminoid.	Free.	Albuminoid.	Free.	Albuminoid.	Free.	Albuminoid.
2, 3, 4, . . .	.0140	.0102	.0073	.0107	.0073	.0095	.0080	.0095
5, 6, 7, . . .	.0150	.0120	.0045	.0097	.0102	.0100	.0102	.0098
8, 9, 13, 14, . .	.0149	.0110	.0070	.0101	.0109	.0099	.0155	.0106
10, 11, 12, . .	.0128	.0113	.0122	.0092	.0112	.0097	.0122	.0097
Average, .	.0142	.0111	.0077	.0099	.0099	.0098	.0115	.0099

Chemical and Bacterial Analyses of the Water in Different Parts of Boston Harbor.

In the latter part of September an examination was made to learn the general condition of the water in all parts of Boston harbor. For this purpose 60 stations were selected, distributed as evenly as practicable in all parts of the harbor, but including a few stations outside its entrance, and at each of these stations samples of water were collected both on the incoming and outgoing tide for chemical and bacterial analysis. The work covered a period of about five days, between September 14 and 29, and the results are plotted on the accompanying map.

During the period covered by the harbor examinations in September, 1905, there was no considerable rainfall, and the waters of the upper harbor were not being polluted by the overflow of considerable quantities of sewage during this period, as would be the case in wet weather.

The outermost station at which samples of water were collected was at Three and One-half Fathom Ledge, six miles east of Deer Island Light; and the next nearest station was located about half a mile north of Outer Brewster Island, four miles from Deer Island Light. At these two stations samples collected on the outgoing tide showed the presence of 27 and 24 bacteria per cubic centimeter respectively, and no coli. A sample collected on the incoming tide in the main channel a little over a mile east of Deer Island Light showed the presence of 22 bacteria per cubic centimeter, and no coli. A sample collected on the incoming tide in the Black Rock channel showed the presence of a larger number of bacteria than at the other stations just referred to, and a larger number was also found in a sample collected between Boston Light and Point Allerton, but no coli were found in either of these samples. All of these stations are outside the harbor.

The only stations within the harbor from which samples of water free from coli were obtained, either upon the incoming or outgoing tide, were in a small channel between Crow Point and Slate Island, Hingham, where a sample collected on the incoming tide was found to contain 36 bacteria per cubic centimeter, and no coli, and at the bridge at Quincy Point, where a sample collected on the incoming tide was found to contain 65 bacteria, but no coli.

The greatest numbers of bacteria found in any of the samples were present in those collected over the sewer outlet at Deer Island, in the neighborhood of the sewer outlet at Moon Island, in the estuary of the Neponset River, and in the main ship channel between Boston and East Boston. The effect of the sewer outlet near Peddock's Island was also marked by the presence of a much larger number of bacteria at a station near this outlet than was found at the other stations in this neighborhood.

Grouping the results in general accordance with the main divisions of the harbor waters, we find that the smallest average number of bacteria found in samples collected within the harbor — *i.e.,* within a line drawn from Deer Island Light to Point Allerton — was in those collected in Hingham bay. In 15 samples collected on the incoming tide in this bay the average number of bacteria was 71, and in 13 samples collected on the outgoing tide the average number found was 86.

Next to Hingham bay, the lowest numbers of bacteria found in the water of any large section of the harbor were found in the region north of the main ship channel between East Boston and Deer Island. The highest numbers were found in the samples collected in the inner harbor and the next highest in those collected in the middle harbor, *i.e.,* in the region around Governor's Island.

The greatest numbers of B. coli were found in the water of Quincy bay, and a larger number was found in Dorchester bay than in any other section of the harbor except Quincy bay. The reason for this is doubtless the fact that some of the stations in Quincy and Dorchester bays were within the area affected by the discharge of sewage at Moon Island. The smallest numbers of coli were found in the waters of Hingham bay.

The results of the chemical analyses correspond very closely to the results of the bacterial analyses. The greatest quantities of free ammonia present in the water of any considerable section of the harbor were found in the waters of the inner harbor and the next highest in the waters of the middle harbor.

The results show that the worst polluted section of Boston harbor at the present time is the portion known as the inner harbor, extending from the neighborhood of Governor's Island and City Point up to the mouths of the Charles and Mystic rivers.

Chemical and Bacterial Analyses of Water from Different Parts of Boston Harbor. (1905.)

Location.	Bacteria.		B. Coli.		Free Ammonia.		Albuminoid Ammonia.		Numbers of Stations at which Samples were collected.[1]
	Incoming Tide.	Outgoing Tide.	Incoming Tide.	Outgoing Tide.	Incoming Tide.	Outgoing Tide.	Incoming Tide.	Outgoing Tide.	
Inner harbor, ...	1,043[2]	1,098	28	30	.0253	.0340	.0131	.0144	9–15
Middle harbor, ...	526	587	29	12	.0174	.0205	.0132	.0110	4–8
North side of main ship channel,	258	197	24	14	.0089	.0126	.0134	.0116	1–3, 18, 19
Dorchester bay, ...	330[3]	251[3]	33	62	.0161	.0195	.0143	.0206	20–30
Quincy bay, ...	327	797	143	117	.0103	.0131	.0115	.0136	32–38, 43, 44
Hingham bay, ...	71	86	4	1	.0076	.0073	.0096	.0108	46–60

[1] Station numbers refer to accompanying map.
[2] Omitting station 11.
[3] Omitting stations 29 and 30.

Examination of the Shores and Islands in Boston Harbor.

In connection with the examination of sewer outlets the shores of the harbor and of the islands were carefully inspected, to determine whether matters from sewage were visible there. The only matters probably derived from the sewage found on these shores are grease balls and particles of grease. More of this matter was found on Long Island opposite the Moon Island sewer outlet than at any other place examined. Considerable quantities were also found on Rainsford Island, and small amounts on Lovell's, Gallup's and George's islands in the general track of the Moon Island sewage on its way to sea. Considerable quantities were also found about the shores of Peddock's Island, which may have come, in part, from the new Peddock's Island outlet, but probably largely from the Moon Island outlet. Next to the Long Island and Peddock's Island shores, grease particles were found in the largest numbers on Governor's Island, some pieces found here being two inches in diameter.

A very little grease was found in small particles on most of the other shores in the harbor except in the southerly part of Hingham bay. A few small pieces were also found outside of Deer Island and along the Winthrop shore toward Grover's Cliff.

These particles of grease form in the sewers generally around some small floating object, such as a match or piece of cork; and, as they float upon the surface of the water when the sewage is discharged, and are not readily broken up, they undoubtedly travel long distances from the outlets. The quantity of such matter is small, and these particles can be found among the seaweed and other débris on the shores usually only by careful search.

Results of the Examinations of Shellfish from Flats in Boston Harbor.

The range of tide in Boston harbor is about 10 feet, and at low tide large areas of flats are exposed in nearly all parts of the harbor, many of which contain clams in considerable numbers. No definite information is available showing the number of clams collected for use as food from the clam flats in Boston harbor; but in the course of the investigation estimates of the probable number of clams taken from each of the different flats have been obtained from various sources, and the general average of these estimates, in the absence of more definite information, appears to be the best indication available as to the extent of the shellfish or clam industry in Boston harbor.

Table showing Extent of Shellfish Industry in Boston Harbor. (1905.)

Location.	Number on Map.	Estimated Quantity per Day when taken.	Market.
Winthrop and Snake Island,	1–9	35 bushels,[1]	Boston–Winthrop, private.
Chelsea Point to East Boston,	10–19	Very few at 17,	Private.
Chelsea River,	20–25	5 bushels at 25,	Boston.
Mystic River,	26–35	15 bushels at 32; 10 bushels at 29.	Boston.
Old harbor,	39–45	3 bushels,	South Boston.
Dorchester bay,	46–72	50 bushels,[2]	Boston.
Moon Island,	73–78	8 bushels,[3]	Nantasket.
Quincy bay,	79–91	5 bushels at Half Moon Island; 5 bushels elsewhere.	Nantasket, private.
Weymouth Fore River,	92–106	5 bushels,[4]	Private or local.
Weymouth Back River,	107–117	3 bushels,	Private.
Hingham harbor,	118–126	8 bushels,	Nantasket, private.
Weir River,	127–135	11 bushels,	Private.
White Head to Allerton,	136–142	5 bushels,	Nantasket.
Apple Island,	143–145	Few,	Private.
Bird Island flats,	149–150	No clams; oysters planted yearly.	
Governor's Island,	151–153	Few,	Private.
Thompson's Island,	154–158	5 bushels,	Boston.
Spectacle Island,	159–161	5 bushels,	Nantasket.
Long Island,	162–167	Few,	Private.
Rainsford Island,	168–169	None.	
Peddock's Island,	170–175	North side, none; south side, 4 bushels.	

[1] Dug mostly near Snake Island.
[2] Dug mostly along east side of river; very few dug from Squantum to Chapel Rock.
[3] Dug either side of roadway.
[4] The larger quantity is dug on northwest shore.

A considerable number of samples of clams had already been collected in the previous year from the flats at several places in Boston harbor, and analyzed, the results showing, especially in the case of those from the flats in the Charles River, the presence of bacteria characteristic of sewage.

In 1905 the work of obtaining samples of clams from various localities in each of the flats was begun early in the season and completed in the latter part of October.

In the collection of the samples usually three clams were taken at each place, and combined at the laboratory and analyzed as a single sample. The analysis consisted in determining whether B. coli were present either in the water in the shell of the clam or in the body of the clam itself. In many cases, owing to the presence of the organism known as sewage *Streptococcus,* the determination of the number of coli present was impracticable, and the presence of the sewage *Streptococcus* has been noted.

The results have, for convenience, been plotted on a chart showing the points at which the samples were taken, and whether the colon Bacillus or sewage *Streptococcus* was present in the sample. In all cases samples of sea water were collected near the points from which the samples of clams were taken; and the results of the bacterial analyses of these samples of water are also presented on the map, showing both the total number of bacteria and the number of B. coli found in the sample.

The following table contains a summary of the results of the analyses, from which it appears that more than three-quarters of the samples of clams collected in various parts of the harbor contained either the colon Bacillus or sewage *Streptococcus,* and about 86 per cent. of the samples of sea water, collected from waters adjacent to the flats, contained the colon Bacillus.

It is said that oysters are kept for fattening on the Bird Island flats at certain periods of the year; but none was found there during these examinations. Neither quahaugs nor scallops are found within the harbor limits.

Summary of Results of the Examinations of Samples of Clams and Sea Water from Boston Harbor. (1905.)

Location.	Number of Samples of Clams examined.	Number containing Coli in Body of Clam.	Number containing Sewage Streptococcus in Body of Clam.	Number containing Coli in Shell Water.	Number containing Sewage Streptococcus in Shell Water.	Number containing neither Coli nor Sewage Streptococcus in Body of Clam nor in Shell Water.	Number of Samples of Sea Water examined.	Number containing Coli or Sewage Streptococcus.	Number free from Coli or Sewage Streptococcus.
Old harbor,	5	2	1	5	0	0	7	7	0
Between Calf Pasture Point and Savin Hill.	5	2	0	5	0	0	5	5	0
Savin Hill to Commercial Point,	2	0	0	0	0	2	2	0	2
North side of Neponset River estuary.	8	2	0	3	0	5	7	2	5
South side of Neponset River estuary.	6	0	0	1	0	5	6	6	0
North side of Squantum,	2	0	2	0	2	0	6	6	0
North side Moon Island causeway,	2	0	2	1	0	0	3	3	0
South side Moon Island causeway,	3	1	1	0	1	1	3	3	0
Squantum to Black's Creek,	6	0	3	2	0	1	4	4	0
Black's Creek to Nut Island,	3	3	0	1	0	0	2	2	0
Weymouth Fore River,	15	9	1	3	5	3	12	11	1
Weymouth Back River,	8	5	3	2	0	0	8	8	0
Weymouth Back River to Crow Point.	0	0	0	0	0	0	3	3	0
Hingham bay,	8	1	4	5	0	1	6	3	3
Nantasket bay,	7	5	1	4	1	1	10	10	0
Hull bay,	6	3	1	2	2	1	6	4	2
Mystic River above Chelsea bridge,	8	5	2	4	0	1	6	6	0
Chelsea River,	3	3	0	3	0	0	6	6	0
East Boston to Chelsea Point,	7	4	2	6	0	1	10	6	4
Chelsea Point to Point Shirley,	7	2	1	1	2	3	7	7	0
Apple Island flats,	1	1	0	1	0	0	3	1	2
Governor's Island flats and Bird Island flats.	3	1	0	1	0	2	5	4	1
Thompson's Island,	3	2	1	2	0	0	5	5	0
Spectacle Island,	2	0	2	1	0	0	3	3	0
Long Island,	3	0	3	3	0	0	6	6	0
Peddock's Island,	2	0	0	0	0	2	3	3	0
Totals,	125	51	30	56	13	29	144	124	20


STATE BOARD OF HEALTH
CHART OF BOSTON HARBOR SHOWING LOCATIONS OF STATIONS AT WHICH SAMPLES OF WATER AND SHELL FISH WERE COLLECTED FOR ANALYSIS
MILES
0 1/4 1/2 3/4 1 2
1905
— EXPLANATION —
The figures enclosed in circles thus (24) represent stations at which samples of sea water were collected for analysis. The figures to the right of the circle give the results of the analyses of samples collected on the incoming tide. Figures to the left give the results of the analyses of samples collected on the outgoing tide. The upper figures show the results of the bacterial examinations, the first figure being the total number of bacteria per c.c. and those to the right of the dash being the number of B. Coli per c.c. When B. Coli was present but the number was not ascertained, the fact is indicated by +. In some cases the determination of the B. Coli was made impossible by an abundant growth of sewage Streptococcus. This fact is indicated by S. The lower figures represent the free ammonia in parts per 100,000.
Example (Station 37) 4400-790 .0210 (37) 70-+ .0115
4400 = Bacteria per c.c. on outgoing tide
790 = B. Coli
.0210 = Free Ammonia
70 = Bacteria per c.c. on incoming
.0115 = Free Ammonia
+ = B. Coli present but not counted
The black dots with a number beneath thus 172 represent stations at which samples of clams and sea water were collected for analysis. The upper figures represent the results of the bacterial analyses of the sea water, the first figures being the number of bacteria per c.c. and those to the right of the dash the number of B. Coli per c.c. The lower figures show the results of the examination of the clams, the first figure giving the number of B. Coli per c.c. in the water contained in the shell of the clam and the figure to the right of the dash the number of B. Coli contained in the body of the clam.
Example (Station 83) 1156-676 83 + - 0
1156 = Bacteria per c.c. in sea water
676 = B. Coli
+ = B. Coli present in water contained in shell of clam
0 = B. Coli not present in body of clam
CHELSEA
MYSTIC RIVER
CHELSEA
CHARLESTOWN
EAST BOSTON
BREEDS ISLAND
GROVERS CLIFF
WINTHROP
CHELSEA PT
SNAKE I.
SHIRLEY PT
DEER ISLAND
CHARLES RIVER
BOSTON
BIRD ISLAND SHOAL
APPLE I.
GOVERNORS I.
SEWER OUTLET
DEER ISLAND LIGHT
SOUTH BOSTON
CASTLE I.
THREE AND ONE HALF FATHOM LEDGE
GREEN I.
LITTLE CALF I.
CALF I.
OUTER BREWSTER
MIDDLE BREWSTER I.
GREAT BREWSTER I.
BOSTON LIGHT
LIGHT HOUSE
LOVELLS I.
GALLUPS I.
ST GEORGES I.
OLD HARBOR
DORCHESTER BAY
COW PASTURE PT
SAVIN HILL
SPECTACLE I.
LONG ISLAND
THOMSONS I.
RAINSFORD I.
CHAPEL ROCKS
MOON I.
SEWER OUTLET
HULL
PT ALLERTON
LITTLE HOG I.
COMMERCIAL PT
SQUANTUM PT
SQUANTUM
NEPONSET RIVER
NEPONSET
ATLANTIC
HANGMANS I.
SEWER OUTLETS
PEDDOCKS ISLAND
QUINCY BAY
HINGHAM BAY
SHEEP I.
BUMKIN I.
WHITE HEAD
WORLDS END
WEIR RIVER
NANTASKET
HALF MOON I.
HOUGHS NECK
GRAPE I.
SLATE I.
BLACKS CREEK
FORE RIVER
CROW POINT
HINGHAM HARBOR
BACK RIVER
WEYMOUTH BACK RIVER
WEYMOUTH FORE RIVER
QUINCY
QUINCY POINT
NORTH WEYMOUTH
HINGHAM

Conclusions.

The results of examinations of the effect of the discharge of sewage into the harbor at the three principal sewer outlets show no material change from the results of the previous investigation five years ago. The investigations in this year have been supplemented by chemical analyses of samples of water collected in the areas affected by the discharge of sewage from the two principal outlets — those at Moon Island and at Deer Island — and from the adjacent waters.

The results of the chemical analyses show that the sewage discharged at the Deer Island outlet does not spread beyond the area visibly affected by the discharge of sewage at this outlet. At Moon Island also the chemical analyses show that the sewage in its course to the sea is confined to the area ordinarily visibly affected, except that the analyses indicate that at this time a considerable quantity of sewage passed out of the harbor north of Long Island.

The results of the bacterial analyses of samples of water from stations in all parts of Boston harbor, including points outside the harbor entrance, both on the incoming and outgoing tide, show that the incoming sea water contains very few bacteria and no coli; but all of the samples from 55 stations within the harbor, with two exceptions, showed the presence of this organism on the incoming tide, and all of the samples collected from stations within the harbor showed, without exception, the presence of the colon Bacillus on the outgoing tide. The greatest numbers of bacteria were found in the immediate neighborhood of the main sewer outlets at Moon Island and Deer Island, and in the neighborhood of the sewer outlet near Peddock's Island; and very large numbers were also found in the upper harbor, into which much sewage is discharged, and in the Neponset River estuary, through which the highly polluted water of the Neponset River finds its way to the sea.

The chemical analyses show, in general, results similar to the bacterial analyses. The water in all parts of the harbor contains more free ammonia than is found in the water outside the harbor. The free ammonia, as well as the number of bacteria, is lowest within the harbor in the waters of Hingham bay, and is highest in the waters of the inner harbor.

The shores of the harbor are in general affected but little by the presence of matters discharged from the main sewer outlets. The only one of the three main outlets at which notable deposits take place is at Moon Island, where considerable quantities of sludge collect near the sea wall on the northeasterly side of the island. The deposits here do not appear to be permanent, and are apparently removed from time to time by the action of the currents and waves.

The results of an examination of the shores of the harbor, for the presence of matters which might be derived from the sewers, show that the only matters which could be identified at this time as probably derived from the sewer outlets were grease balls and particles of grease. The grease balls, so called, are formed in the sewers usually around pieces of cork, matches or other floating objects, and, when discharged into the harbor water, float upon the water and may be carried long distances from the outlet. This matter was found in considerable quantity on the shores of Long Island, and in lesser quantity on the shores of Peddock's and Governor's islands. Small quantities were also found on the islands near the mouth of the harbor, and on the shores of the mainland in most portions of the harbor excepting the southerly part of Hingham bay.

In general, the harbor is free from the appearance of sewage pollution, except in the neighborhood of the main sewer outlets, as already described. The analyses show that the waters of the upper portion of the harbor are more polluted at the present time than the waters of any other portion except in the immediate neighborhood of the main sewer outlets. Much of this pollution is caused by the direct discharge into the harbor of sewage from the sewers in Chelsea and in some other places. If this sewage should be discharged into the metropolitan system, — which was designed to receive it, — much of the pollution of the upper harbor would be prevented. A very material additional improvement could be made if the buildings and wharves on the harbor front, especially in the city of Boston, should be connected with the local sewers.

The results of the examination of samples of clams from 125 localities, covering all portions of the harbor in which these shellfish could be found, showed the presence of the colon Bacillus or sewage *Streptococcus* either in the shell water or in the body of the clam in 96 of the samples, or about 77 per cent. of those examined. Out of the 144 samples of sea water collected at points opposite the clam flats, 124, or about 86 per cent., contained either the colon Bacillus or sewage *Streptococcus*.

The results of the investigation have shown that the waters in all parts of the harbor are affected in a greater or less degree by pollution from the sewers and other wastes from the great population about it; and there can be no question of the serious danger to health involved in the use of shellfish from any point within the harbor or in the neighborhood of the islands at its mouth, if these shellfish are used for food without thorough cooking.

STUDIES AT THE LAWRENCE EXPERIMENT STATION

ON THE

POLLUTION OF SHELLFISH.

By H. W. CLARK, *Chemist of the Board.*

STUDIES AT THE LAWRENCE EXPERIMENT STATION ON THE POLLUTION OF SHELLFISH.

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In July, 1900, work was begun at the Lawrence Experiment Station concerning the determination by bacterial methods of the pollution of shellfish, together with the examination of many samples of shellfish from different sources. Five and one-half years have now elapsed since this work was started, and considerable information on the subject has accumulated.

The work has been divided into seven parts: (1) studies of the literature of the subject, and of typhoid epidemics caused or supposed to have been caused by eating raw shellfish; (2) studies of methods for the bacterial examination of shellfish; (3) studies of the relative viability of B. coli and B. typhosus; (4) studies of the length of time that shellfish, when kept under market or natural conditions, may remain infected with B. coli or other sewage bacteria; (5) studies of the possibility of the destruction of B. coli in the digestive tract of shellfish; (6) heat tests, to show whether or not shellfish are sterilized by the ordinary methods of cooking and during the time generally employed in cooking; (7) studies of a polluted clam flat, to see if the limit of the area of pollution can be accurately determined.

The first report, containing a review of the literature of the subject, was published in Senate Document, No. 336, 1902. The most important contribution to this literature during the past few years has been made by the Royal Commission upon sewage disposal of Great Britain, and will be referred to later.

Tests upon the relative viability of B. coli and B. typhosus, when placed under similar adverse conditions, have been reported upon, and have shown, as have further tests, — and, indeed, tests made in many laboratories, — that under similar conditions these bacilli are about equally resistant, although B. coli is somewhat the hardier.

In the bacterial work, tests for the presence of B. coli in the water in the shellfish and in the body of the fish itself have always been made,

and many determinations of other sewage bacteria have also been made, especially of Houston's sewage *Streptococcus*. These tests have been carried out in the usual manner for the determination of these bacteria, and it has been shown by many results that tests for B. coli alone might at times be misleading, since the hardier and more quickly growing bacilli in the polluted water surrounding some clam flats, and in the water and body of the clam itself, overgrow and kill out B. coli.

Studies on the Examination of Various Portions of Shellfish for the Detection of Infection.

In the study of the best method of examination of shellfish for the determination of evidence of pollution, much work has been done, and tests upon shell water, gills, stomach, rectum, liver, visceral tissue, etc., have been made. The results of these tests are shown in a following series of tables.

Tests with different portions of the body of the clam have shown that the intestine, which really includes the entire alimentary tract, is somewhat more likely to give evidence of infection, if present, than any other portion of the body. It is a simple process, however, to test the entire clam, and in this way a greater percentage of positive indications of pollution is obtained; although B. coli or other sewage bacteria detected in this way may, of course, be present on the outer portions of the body.

Bacterial Examination of Different Portions of the Body of Shellfish.

Table No. 1. — *Dec. 31, 1903: Tests for B. Coli in Various Portions of 5 Clams. Clams obtained from a Lawrence Dealer. Portions tested: (1) Shell Water; (2) Gills; (3) Stomach (Intestine); (4) Rectum (Intestine); (5) Liver; (6) Visceral Tissue.*

	Per Cent. of Samples in which Preliminary Fermentation occurred.	Per Cent. of Samples giving Positive Tests for —		
		B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Shell water,	40	20	40	20
Gills,	20	0	0	0
Stomach (intestine),	20	20	0	0
Rectum (intestine),	40	20	0	0
Liver,	0	0	0	0
Visceral tissue,	0	0	0	0

TABLE No. 2.—*Jan. 5, 1904: Clams from a Lawrence Dealer, placed in Polluted Water over Night. Five Clams tested for B. Coli in Different Portions. Portions tested: (1) Shell Water; (2) Gills; (3) Stomach (Intestine); (4) Rectum (Intestine); (5) Liver; (6) Visceral Tissue.*

	Per Cent. of Samples in which Preliminary Fermentation occurred.	PER CENT. OF SAMPLES GIVING POSITIVE TESTS FOR—		
		B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Shell water,	100	100	40	40
Gills,	100	100	30	30
Stomach (intestine),	30	30	10	10
Rectum (intestine),	70	50	20	0
Liver,	20	30	10	0
Visceral tissue,	10	10	20	10

TABLE No. 3.—*Clams from a Lawrence Dealer, originally from Newburyport. Placed in Polluted Water over Night. Ten Clams tested for B. Coli in Six Different Portions: (1) Shell Water; (2) Gills; (3) Stomach (Intestine); (4) Rectum (Intestine); (5) Liver; (6) Visceral Tissue.*

	Per Cent. of Samples in which Preliminary Fermentation occurred.	PER CENT. OF SAMPLES GIVING POSITIVE TESTS FOR—		
		B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Shell water,	100	90	50	40
Gills,	100	80	20	20
Stomach (intestine),	70	30	20	10
Rectum (intestine),	90	40	50	20
Liver,	50	40	10	10
Visceral tissue,	40	20	0	0

TABLE No. 4.—*March 2, 1904: Clams from Newburyport, from Location where B. Coli were found in Greatest Per Cent. of Samples. Ten Clams tested in Different Portions of Anatomy: (1) Shell Water; (2) Gills; (3) Stomach (Intestine); (4) Rectum (Intestine); (5) Liver; (6) Visceral Tissue.*

	Per Cent. of Samples in which Preliminary Fermentation occurred.	PER CENT. OF SAMPLES GIVING POSITIVE TESTS FOR—		
		B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Shell water,	100	100	50	50
Gills,	70	30	40	10
Stomach (intestine),	70	50	40	20
Rectum (intestine),	100	60	70	20
Liver,	50	0	30	0
Visceral tissue,	10	0	10	0

Studies of Digestion.

In a study upon digestion, 280 clams were examined. The clams were obtained from Newburyport, placed in a mixture of equal parts of Lawrence sewage and sea water for a number of hours, in order to become infected with B. coli and other sewage bacteria, then placed on ice, and 10 of them tested daily for B. coli and the sewage *Streptococcus* in both the shell water and intestines. The results of the experiments are given in following tables, and show that even at the end of fourteen days the intestines of a large number of the clams gave positive tests for B. coli and the sewage *Streptococcus,* thus showing the resistance of these organisms to the digestive processes of the clam. This period of fourteen days was as long as the clams could be kept alive on ice.

Tables showing Percentage of Positive Tests for B. Coli and Sewage Streptococcus in Clams kept upon Ice for Fourteen Days.

Table No 1. — *Experiment No. 126.*

	Preliminary Fermentation.			Positive Tests for B. Coli.				Positive Tests for Streptococcus.				Positive Tests for B. Coli and Streptococcus.		
	Shell Water.	Intestine.	Both Shell Water and Intestine.	Either Shell Water or Intestine.	Shell Water.	Intestine.	Both Shell Water and Intestine.	Either Shell Water or Intestine.	Shell Water.	Intestine.	Both Shell Water and Intestine.	Shell Water.	Intestine.	Both Shell Water and Intestine.
Start,	100	100	100	80	60	80	60	90	80	50	40	50	40	20
1,	100	100	100	90	80	70	60	40	30	20	10	20	20	10
2,	100	100	100	90	40	90	40	100	90	60	50	40	50	20
3,	100	100	100	80	60	60	40	50	50	20	20	30	20	10
4,	100	100	100	100	80	90	70	70	60	50	40	40	40	20
5,	100	100	100	90	60	90	60	70	60	40	30	20	30	0
6,	100	100	100	90	80	60	50	90	70	80	60	50	50	20
7,	100	100	100	100	80	90	70	100	90	70	60	70	60	40
8,	100	100	100	100	100	60	60	100	100	70	70	100	50	50
9,	100	100	100	100	90	80	70	90	80	70	60	70	60	40
10,	100	100	100	90	80	80	70	100	100	80	80	80	60	50
11,	100	100	100	100	90	80	70	90	90	60	60	80	40	30
12,	100	100	100	90	60	60	30	100	80	90	70	40	60	10
13,	100	100	100	70	30	50	10	100	90	80	70	20	50	0
14,	100	100	100	70	60	50	40	100	100	90	90	60	50	40

TABLE No. 2. — *Experiment No. 132.*

	Preliminary Fermentation.			Positive Tests for B. Coli.				Positive Tests for Streptococcus.				Positive Tests for B. Coli and Streptococcus.		
	Shell Water.	Intestine.	Both Shell Water and Intestine.	Either Shell Water or Intestine.	Shell Water.	Intestine.	Both Shell Water and Intestine.	Either Shell Water or Intestine.	Shell Water.	Intestine.	Both Shell Water and Intestine.	Shell Water.	Intestine.	Both Shell Water and Intestine.
Start, . .	100	100	100	80	80	60	60	100	90	90	80	80	50	50
2, . . .	100	100	100	80	70	40	30	100	20	80	0	10	20	0
4, . . .	100	100	100	80	60	50	30	100	30	100	30	20	50	20
6, . . .	100	100	100	80	80	40	40	100	50	90	40	30	30	10
8, . . .	100	80	80	90	80	50	40	70	30	70	30	10	40	10
10, . . .	100	100	100	90	90	20	20	80	70	80	70	60	10	10
12, . . .	100	100	100	70	20	60	10	90	90	70	70	20	30	10
14, . . .	100	100	100	60	20	50	10	100	90	50	40	10	0	0

Sterilization by Heat.

In the study of sterilization of shellfish by the ordinary methods of cooking many experiments have been made: 18 with clams collected from the Newburyport flats, and 2 with clams bought from a Lawrence dealer. The results of all of these heat tests are given in tables on the following pages.

Unshucked Clams in Boiling Water.

In this work, in the first place, 6 experiments were carried out in which unshucked clams were placed in water, which was then slowly brought to the boiling point. Careful records of temperature and time were kept, and clams were taken out for examination from time to time. As a result of these experiments, it was found that a boiling heat was certainly required at times to kill all the bacteria present in some of the clams, although generally a large proportion of the latter became sterile at a lower temperature. On four occasions either B. coli or the *Streptococcus,* or both, were found in the intestines of clams taken from water which had been kept at the boiling temperature for several minutes. The tables showing these results follow: —

TABLE No. 1. — *Tests for B. Coli and Streptococcus in Newburyport Clams heated to Different Temperatures.*

Sample Number.	Elapsed Time (Min.).	Tempera-ture (Deg. C.).	Preliminary Fermentation.		B. Coli found.		Streptococcus found.	
			Water.	Intestine.	Water.	Intestine.	Water.	Intestine.
1, ...	0	20	+	+	0	0	0	+
2, ...	0	20	+	+	0	0	0	+
3, ...	0	20	+	+	0	0	0	+
4, ...	0	20	+	+	+	0	0	0
5, ...	0	20	+	+	0	+	0	0
6, ...	0	20	+	+	0	0	0	0
7, ...	18	40	+	+	0	0	0	+
8, ...	18	40	+	+	+	0	0	+
9, ...	42	60	0	+	0	+	0	0
10, ...	42	60	0	0	0	0	0	0
11, ...	67	80	0	+	0	0	0	0
12, ...	67	80	0	0	0	0	0	0
13, ...	82	100	0	0	0	0	0	0
14, ...	82	100	0	+	0	0	0	+
15, ...	84	100	0	0	0	0	0	0
16, ...	84	100	0	+	0	0	0	+

B. enteritidis sporogenes (Klein) found in intestine after boiling two minutes.

At 40 degrees C. all clams were dead and shells open. Water samples were taken directly from the water in the dish.

TABLE No. 2. — *Tests for B. Coli and Streptococcus in Newburyport Clams heated to Different Temperatures.*

Sample Number.	Elapsed Time (Min.).	Tempera-ture (Deg. C.).	Preliminary Fermentation.		B. Coli found.		Streptococcus found.	
			Water.	Intestine.	Water.	Intestine.	Water.	Intestine.
1, ...	0	20	+	+	0	0	0	0
2, ...	0	20	+	+	+	0	0	+
3, ...	0	20	+	0	0	0	0	0
4, ...	0	20	0	+	0	0	0	0
5, ...	9	40	+	+	0	0	0	+
6, ...	9	40	0	+	0	0	0	0
7, ...	40	60	-	+	-	0	-	+
8, ...	40	60	-	+	-	+	-	0
9, ...	50	80	-	+	-	0	-	+
10, ...	50	80	-	+	-	0	-	+
11, ...	65	100	-	+	-	0	-	+
12, ...	65	100	-	+	-	0	-	+
13, ...	67	100	-	0	-	0	-	0
14, ...	67	100	-	+	-	+	-	0

At 60 degrees all the shells were open, and water samples were not tested.

The clams were from the same lot as tested in Experiment No. 1, after being kept on ice six days.

TABLE NO. 3. — *Tests for B. Coli in Clams heated to Different Temperatures.*

Number of Samples Taken.	Elapsed Time (Min.).	Temperature (Deg. C.).	Number of Samples giving Preliminary Fermentation.		Number of Samples in which B. Coli was found.	
			Water.	Intestine.	Water.	Intestine.
2, ...	Start.	20	6	6	1	1
2, ...	18	40	2	2	1	0
2, ...	42	60	0	1	0	1
2, ...	67	80	0	1	0	0
2, ...	82	100	0	1	0	0
2, ...	84	100	0	1	0	0

TABLE NO. 4. — *Tests for B. Coli in Clams heated to Different Temperatures.*

Number of Samples Taken.	Elapsed Time (Min.).	Temperature (Deg. C.).	Number of Samples giving Preliminary Fermentation.		Number of Samples in which B. Coli was found.	
			Water.	Intestine.	Water.	Intestine.
4, ...	Start.	20	3	3	1	0
2, ...	9	40	1	2	0	0
2, ...	40	60	-	2	-	1
2, ...	50	80	-	2	-	0
2, ...	65	100	-	2	-	0
2, ...	67	100	-	1	-	1

Clams used in No. 4 were from the same lot as those in No. 3, having been kept on ice six days, to duplicate the effect of storage in a dealer's hands. Tests were not made of the water in the shell in this experiment above 40 degrees C., the clams being all dead and the shells open at sixty degrees C.

TABLE NO. 5. — *Tests for B. Coli in Newburyport Clams heated to Different Temperatures for a Given Period.*

Number of Samples Taken.	Time in Water (Min.).	Temperature (Deg. C.).	Number of Samples giving Preliminary Fermentation.		Number of Samples in which B. Coli was found.	
			Water.	Intestine.	Water.	Intestine.
3, ...	Start.	20	-	1	0	0
2, ...	10	40	-	2	-	1
2, ...	10	60	-	1	-	0
2, ...	10	80	-	0	-	0
2, ...	2	100	-	1	-	0

TABLE No. 6. — *Tests for B. Coli in Wells Beach Clams kept at Different Temperatures for a Given Period.*

Number of Samples Taken.	Time in Water (Min.).	Temperature (Deg. C.).	Preliminary Fermentation.		B. Coli found.	
			Water.	Intestine.	Water.	Intestine.
1,[1]	Start.	20	+	+	+	+
1,[1]	10	40	+	+	+	+
1,[1]	10	60	-	+	-	+
1,[1]	10	80	-	+	-	0
1,[1]	2	100	-	+	-	0

[1] Mixed sample of 3 clams in each case.

Shucked Clams in Boiling Water.

Experiments were then made upon shucked clams placed in boiling water for various periods, as follows: clams from the most polluted portion of the flats at Newburyport were taken, and 5 lots, of 5 clams each, were placed in boiling water for one, two, three, four and five minutes, respectively. Tests for B. coli in the intestine were made. Neither B. coli nor the sewage *Streptococcus* was found after one minute's boiling, although fermentation occurred in certain samples after five minutes' immersion in boiling water.

TABLE No. 1.

Number of Minutes in Boiling Water.	Per Cent. of Samples giving Positive Tests.			
	Fermented.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
1, ...	100	0	0	0
2, ...	20	0	0	0
3, ...	60	0	0	0
4, ...	100	0	0	0
5, ...	60	0	0	0

Clams taken from badly polluted portions of the flats at Newburyport were taken, and 5 lots of 10 clams each were placed in boiling water for one, two, three, four and five minutes, respectively. Tests were made for B. coli in the intestines. Neither B. coli nor the sewage *Streptococcus* was found even after one minute's boiling, although 40 and 70 per cent. of the raw clams gave positive tests for these two germs.

Some of the clams, however, were not sterilized by even five minutes' immersion in boiling water, as was shown by the fermentation tests.

TABLE No. 2.

Number of Minutes cooked.	Per Cent. of Samples giving Positive Tests.			
	Fermented.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Raw clams,	100	40	70	10
1 minute,	100	0	0	0
2 minutes,	90	0	0	0
3 minutes,	70	0	0	0
4 minutes,	100	0	0	0
5 minutes,	90	0	0	0

Clam Chowder.

Following this, two lots of clam chowder were made in the laboratory on different days. When the liquid began to boil, clams were introduced for varying periods. The raw clams used gave 30 per cent. of positive tests for B. coli, and 100 per cent. for the sewage *Streptococcus,* but neither germ was found after five minutes' boiling. The table showing the results follows: —

TABLE No. 1.—*Experiment No. 172, Aug. 10, 1904.*

Number of Minutes cooked.	Number of Clams tested.	Per Cent. of Samples giving Positive Tests.			
		Preliminary Fermentation.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Raw clams,	10	100	30	100	30
5 minutes,	5	40	0	0	0
15 minutes,	5	60	0	0	0
30 minutes,	5	0	0	0	0
60 minutes,	5	60	0	0	0

On Jan. 18, 1904, 25 clams from a chowder were obtained at a Lawrence restaurant and tested for B. coli, but none of the samples gave even the preliminary fermentation test.

Steamed Clams.

Five experiments upon sterilization by steaming were made. In this work it was found that the shells are opened by a temperature much less than that required to sterilize the clam, although clams prepared in this way are considered to be cooked when the shells open. Cooking in this manner, for a period long enough to insure sterilization, causes

the clam to become soft and slimy; further cooking changes it to a leathery mass.

On Jan. 21, 1904, clams said to have come from Wells Beach, Me., were obtained from a Lawrence dealer, and they were placed over night in a mixture of water and 5 per cent. of sewage, and 10 of them were then tested for B. coli and the sewage *Streptococcus*. Three lots of 10 each were then exposed to steam in an Arnold sterilizer for periods of five, ten and fifteen minutes, respectively, after which they were plunged into cold water for a few moments and then tested for B. coli. The results follow, and show that B. coli was found in the intestines of as large a percentage after fifteen minutes' steaming as in the uncooked clams.

TABLE No. 1.

Number of Minutes cooked.	Per Cent. of Samples giving Positive Tests.			
	Preliminary Fermentation.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Raw clams,	70	10	10	0
Steamed clams: —				
5 minutes,	50	10	0	0
10 minutes,	40	10	0	0
15 minutes,	30	10	0	0

On Feb. 10, 1904, clams from Newburyport, obtained at a Lawrence restaurant, were kept over night in a mixture of salt water and 5 per cent. of sewage. Three lots of 10 clams each were then exposed to steam in the Arnold steam sterilizer for five, ten and fifteen minutes, respectively, after which tests were made for B. coli in the intestines. Ten of the raw clams were also tested as controls. The results follow, and show that B. coli and the sewage *Streptococcus* were found after ten minutes' steaming, but not after fifteen.

TABLE No. 2.

Number of Minutes cooked.	Per Cent. of Samples giving Positive Tests.		
	Preliminary Fermentation.	B. Coli.	Streptococcus.
Raw clams,	80	30	90
Steamed clams: —			
5 minutes,	80	20	50
10 minutes,	10	10	20
15 minutes,	0	0	0

March 3, 1904, 3 lots of 10 clams each were cooked in steam for five, ten and fifteen minutes, respectively. Two of them were not killed after five minutes' exposure to steam, and B. coli was found within them. *Streptococcus* was found after ten minutes' steaming.

TABLE NO. 3.

NUMBER OF MINUTES COOKED.	PER CENT. OF SAMPLES GIVING POSITIVE TESTS.			
	Preliminary Fermentation.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Steamed clams: —				
5 minutes,	100	10	50	0
10 minutes,	100	0	40	0
15 minutes,	70	0	0	0

Raw clams from Newburyport from the usual polluted place. The results, given in the following table, show that ten minutes' steaming was required to kill B. coli and the *Streptococcus.*

TABLE NO. 4.

NUMBER OF MINUTES COOKED.	Number of Clams tested.	PER CENT. OF SAMPLES GIVING POSITIVE TESTS.			
		Preliminary Fermentation.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Raw clams,	10	100	30	100	30
5 minutes,	5	100	20	100	20
10 minutes,	5	80	0	0	0
15 minutes,	5	80	0	0	0
30 minutes,	5	100	0	0	0
45 minutes,	5	80	0	0	0
60 minutes,	5	60	0	0	0

One hundred clams tested. Sixty per cent. contained B. coli. No B. coli found after five minutes' steaming, but *Streptococcus* found after thirty minutes' exposure.

TABLE No. 5.— *Experiment No. 166, June 24, 1904.*

Number of Minutes cooked.	Number of Clams tested.	Per Cent. of Samples giving Positive Tests.											
		Preliminary Fermentation.			B. Coli.			Streptococcus.			B. Coli and Streptococcus.		
		Shell Water.	Intestine.	Shell Water and Intestine.	Shell Water.	Intestine.	Shell Water and Intestine.	Shell Water.	Intestine.	Shell Water and Intestine.	Shell Water.	Intestine.	Shell Water and Intestine.
Raw clams,	10	100	100	100	60	60	50	30	60	30	20	30	10
5 minutes,	10	-	100	-	-	0	-	-	100	-	-	0	-
10 minutes,	10	-	100	-	-	0	-	-	100	-	-	0	-
15 minutes,	10	-	100	-	-	0	-	-	80	-	-	0	-
20 minutes,	10	-	100	-	-	0	-	-	100	-	-	0	-
25 minutes,	10	-	100	-	-	0	-	-	60	-	-	0	-
30 minutes,	10	-	100	-	-	0	-	-	40	-	-	0	-
40 minutes,	10	-	100	-	-	0	-	-	0	-	-	0	-
50 minutes,	10	-	100	-	-	0	-	-	0	-	-	0	-
60 minutes,	10	-	100	-	-	0	-	-	0	-	-	0	-

Fried Clams.

Polluted clams shucked, washed, rolled in corn meal and fried with salt pork for varying periods. After five minutes' cooking, clams would be considered ready to be eaten. After fifteen to thirty minutes they were fried crisp and hard, so that it was impossible to separate the intestine from the rest of the body; and samples were taken by cutting off the outside of the body, and placing the whole interior of the body in fermentation tubes. Examination for B. coli and the sewage *Streptococcus* after five minutes' frying gave negative results.

TABLE No. 1.

Number of Minutes cooked.	Number of Clams tested.	Per Cent. of Samples giving Positive Tests.			
		Preliminary Fermentation.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Raw clams,	10	100	60	60	30
5 minutes,	5	100	0	0	0
15 minutes,	5	100	0	0	0
30 minutes,	5	100	0	0	0

A second lot of clams, rolled in corn meal and fried with salt pork for varying periods, gave the same results as previous experiment, as shown by the following table:—

TABLE NO. 2.

Number of Minutes cooked.	Number of Clams tested.	Per Cent. of Samples giving Positive Tests.			
		Preliminary Fermentation.	B. Coli.	Streptococcus.	Both B. Coli and Streptococcus.
Raw clams,	10	100	30	100	30
5 minutes,	5	80	0	0	0
15 minutes,	5	80	0	0	0
30 minutes,	5	40	0	0	0

On Dec. 21, 1903, a pint of shucked clams was obtained from a Lawrence restaurant. The intestines of 20 of them were removed and tested for B. coli, with the following results: —

One hundred per cent. of the samples fermented dextrose. B. coli was found in 75 per cent., the sewage *Streptococcus* in 70 per cent., and both B. coli and the sewage *Streptococcus* were found in 50 per cent. of the samples.

On Dec. 22, 1903, a pint of fried clams was obtained from the same restaurant. These clams were supposed to be of the same lot as the raw clams previously tested. Twenty of these were tested for B. coli, tests being made on that portion of the alimentary canal nearest the center of the visceral mass. On Jan. 8, 1904, a second pint of fried clams was obtained from the same restaurant, and 30 of them were tested for B. coli, tests being made on that portion of the alimentary canal nearest the center of the visceral mass.

Of the 50 fried clams examined in these 2 lots, all showed growth in the fermentation tube, and 28 per cent. of the samples showed gas production. Neither B. coli nor the sewage *Streptococcus,* however, was found in any of the samples. In 4 samples cultures of bacteria were obtained which resembled B. coli in some ways, but these organisms were all spore-forming bacteria.

STUDIES OF OYSTERS.

In the continuance of this work the pollution of oysters bought in the open market was investigated, and also the destruction of bacteria, such as B. coli, by digestion, when oysters are kept under market conditions. A number of experiments upon the degree of heat necessary to kill bacteria within the oyster also were made. In this last work the oysters were cooked according to ordinary methods.

Examination of Raw Oysters.

Seven lots of oysters, each lot containing from 100 to 150, were obtained from Boston dealers, care being taken to obtain the oysters as soon as possible after their arrival in the market. These 7 lots were stated by the dealers to be from 4 different localities, and included Blue Points, — a common name in the Boston market for oysters obtained from Long Island or portions of the Connecticut coast, — Warehams, Cotuits, and oysters from Bullock's Cove on Cape Cod.

From each lot, 20 or 25 were taken for examination as to pollution of the shell water and the intestines, and the same number for experiments upon the detection of B. coli and the sewage *Streptococcus.* The shell water and the crushed body of the oyster were examined together by inserting the entire mass in a fermentation tube, and if fermentation was obtained, carrying out the cultural tests. With each lot, also, a number of cooking experiments were made. The first table beyond shows the results of the examination of the oysters as received.

The shell water in a considerable percentage of all these oysters contained B. coli or the sewage *Streptococcus,* or both, as shown in the table, although 1 lot of Cotuits did not show the presence of B. coli, either in the shell water or intestines; and 1 lot of Blue Points and 1 lot of Bullock's Cove did not show B. coli in the intestines, although present in the shell water. The samples of shell water and the mashed body of the oyster, examined in the manner previously stated, showed the presence of B. coli in a considerable percentage of each lot, with the exception of the 1 lot of Cotuits, previously mentioned. One lot of Wareham oysters did not show *Streptococcus* in the mixed samples of shell water and oyster. A table showing all these results follows: —

Examination of Raw Oysters as received from Boston Dealers. Experiments Nos. 224, 227, 230, 232, 235, 239, and 242.

Kind of Oyster.	Experiment Number.	Number of Oysters tested.	Per Cent. of Samples giving Positive Tests.								
			Shell Water.			Intestine.			Mash.		
			Fermented.	B. Coli Present.	Streptococcus Present.	Fermented.	B. Coli Present.	Streptococcus Present.	Fermented.	B. Coli Present.	Streptococcus Present.
Blue Points,	224	20	80	56	64	25	0	5	85	51	17
Blue Points,	227	20	100	80	10	85	25	43	100	50	20
Warehams,	230	25	24	16	20	20	4	0	48	12	0
Cotuits,	232	20	90	36	18	35	11	7	45	10	20
Cotuits,	235	20	20	0	15	25	0	5	25	0	10
Bullock's Cove,	239	20	100	90	90	20	0	0	70	56	49
Warehams,	242	20	85	77	30	40	10	10	95	38	48

Experiment No. 149. Viability of B. Coli in Oysters.

One hundred and fifty Blue Point oysters, so called, and stated to be only twenty-four hours from the oyster beds, were obtained from a Boston dealer. Ten of them were tested at once, and found to be free from B. coli. The remainder were placed in badly polluted water for a few hours, then placed on ice and 10 of them tested each day. The results, given in a following table, show that even at the end of fourteen days a considerable percentage of the oysters contained B. coli both in their shell water and intestines; that is, the digestive power of the oyster was no greater than that of the clam in the destruction of B. coli. The results show, however, that either only a few of the oysters became infected with the sewage *Streptococcus*, or that this germ was killed by digestion or other means during the experiment. The oysters, as received from the dealer, were, judging from the 10 tested, free from pollution, as neither B. coli nor the sewage *Streptococcus* was found in either the shell water or intestines.

Days.	Fermented.			Per Cent. of Samples giving Positive Tests for —										
				B. coli.				Streptococcus.				B. coli and Streptococcus.		
	Shell Water.	Intestine.	Shell Water and Intestine.	Either Shell Water or Intestine.	Shell Water.	Intestine.	Shell Water and Intestine.	Either Shell Water or Intestine.	Shell Water.	Intestine.	Shell Water and Intestine.	Shell Water.	Intestine.	Shell Water and Intestine.
-[1] . . .	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Start, . . .	100	40	40	90	80	50	40	20	20	0	0	20	0	0
2, . . .	100	20	20	90	70	60	40	0	0	0	0	0	0	0
4, . . .	90	10	10	60	60	0	0	10	10	0	0	10	0	0
6, . . .	100	20	20	30	20	10	0	0	0	0	0	0	0	0
8, . . .	100	60	60	60	60	30	30	0	0	0	0	0	0	0
10, . . .	100	60	60	90	90	60	60	0	0	0	0	0	0	0
12, . . .	100	20	20	90	90	20	20	0	0	0	0	0	0	0
14, . . .	100	30	30	70	70	40	40	0	0	0	0	0	0	0

[1] Oysters as received from dealer.

Experiment No. 222. Viability of B. Coli in Oysters.

One hundred oysters from a Boston dealer, placed over night in a solution of 3 per cent. sea salt in tap water, to which was added 5 per cent. of regular sewage. Oysters before treatment were free from B. coli except in shell water. Tests for B. coli and sewage *Streptococcus* were made at frequent intervals over a period of seventeen days, at which time the supply of living oysters was exhausted. The results are given in the following table: —

	Per Cent. of Samples giving Positive Tests.							
	Fermented.		B. coli.		Streptococcus.		Both B. coli and Streptococcus.	
	Shell Water.	Intestine.	Shell Water.	Intestine.	Shell Water.	Intestine.	Shell Water.	Intestine.
Raw oysters before inoculation,	40	40	20	0	20	0	0	0
Start,	60	30	30	10	0	0	0	0
2 days,	80	10	40	0	0	0	0	0
4 days,	80	50	20	0	0	0	0	0
7 days,	100	10	70	0	0	0	0	0
9 days,	90	20	40	0	0	0	0	0
11 days,	70	0	30	0	0	0	0	0
14 days,	70	50	60	10	0	0	0	0
17 days,	70	30	30	10	0	0	0	0

Experiment No. 216. Inoculation of Oysters with B. Coli.

Oysters were obtained from a Boston dealer, and attempts were made to inoculate them with B. coli in two different ways: One lot placed for two days in a solution of 3 per cent. sea salt in tap water, to which was added 2 per cent. of sewage; another lot placed for two days in a solution of 3 per cent. sea salt in tap water, and a strong broth culture of B. coli added. Tests were made for B. coli and sewage *Streptococcus* in the raw oysters and in the oysters which had been inoculated by each method, and these bacteria proved to be present in a considerable number of the samples tested, as shown by the following table: —

	Number of Oysters tested.	Per Cent. of Samples giving Positive Tests.							
		Fermented.		B. coli.		Streptococcus.		Both B. coli and Streptococcus.	
		Shell Water.	Intestine.	Shell Water.	Intestine.	Shell Water.	Intestine.	Shell Water.	Intestine.
Raw oysters,	5	40	20	20	0	0	0	0	0
Inoculated with sewage,	10	100	40	50	30	0	0	0	0
Inoculated with broth culture of B. coli.	10	100	90	50	50	50	40	0	0

Examinations of Cooked Oysters obtained from Different Restaurants, and Experiments in Regard to the Destruction of Bacteria by Cooking.

A lot of oyster stew from Restaurant No. 1, Boston, was obtained at 2 P.M. and examined at 5.30 P.M. The milk of the stew contained 550 bacteria per cubic centimeter, but the 5 oysters examined were free from bacteria. On the same day a sample of oyster stew was obtained from

Restaurant No. 2, Boston; the oysters were free from bacteria of the colon type, and the milk contained 115 bacteria per cubic centimeter. A sample of oyster stew was obtained from Restaurant No. 1, Lawrence; the milk contained 83 bacteria per cubic centimeter, but the oysters examined were free from bacteria of the colon type. On the same day a sample of oyster stew was obtained from Restaurant No. 2, Lawrence; the oysters contained no bacteria of the colon type, the milk containing 20 bacteria per cubic centimeter. From Restaurant No. 3, Lawrence, a sample of oyster stew, obtained the same day, showed the oysters to be free from bacteria of the colon type, and the milk to contain 325 bacteria per cubic centimeter. Although the oysters in all of these samples were free from bacteria of the colon type, bacteria were present, as shown by the tests. Cooking experiments in the laboratory were as follows: —

Of the 7 lots of oysters, previously described on page 441 of this report, obtained from Boston dealers, a certain number from each lot were polluted by placing them in a mixture of sea water and sewage for a number of hours, in preparation for various experiments upon the destruction of bacteria by cooking.

The first experiments were in regard to cooking oysters in milk, after the manner of making oyster stew. Ten of the raw oysters used were examined in each instance for B. coli and the sewage *Streptococcus,* and these bacteria proved to be present in a large percentage of the oysters used. The first experiments were made by placing the oysters in milk and bringing the latter slowly to boiling temperature and then boiling for a certain period, the oysters being taken from the milk when the latter had reached different temperatures before boiling and after a certain number of minutes' boiling. In the first experiment, all B. coli and *Streptococci* were killed by the time the milk had reached the boiling temperature; and the same result followed with the second experiment. In the third experiment, the oysters were not placed in the milk until it had reached the boiling temperature, this being the common way of making oyster stew. Making the stew in this way, it was necessary that the oysters remain in it at the boiling temperature for five minutes before all bacteria were killed.

Four experiments upon the destruction of bacteria by frying were made, as shown in a following table. In these experiments it will be noticed that, while B. coli and the sewage *Streptococcus* were generally killed by a few minutes' frying, at times they resisted heat for a longer period, the reasons seeming to be that, by this method of cooking, the surface of the oyster becomes hardened, and it is more or less difficult for the heat to penetrate.

Four experiments were made in regard to sterilization of oysters by cooking them in the form known as "escalloped oysters." By this method the heat is largely retained within the mass of oysters and cracker crumbs. In every instance the oysters and the mixture were sterile when properly cooked, as shown by a following table; that is to say, the bacteria were killed after from fifteen to thirty minutes' cooking at ordinary oven temperatures, — the period necessary for satisfactory cooking of this dish.

Experiments Nos. 225, 243 and 226. Oyster Stew.

Oysters were inoculated with B. coli by being placed over night in badly polluted salt water. In Experiments Nos. 225 and 243 the oysters were placed in cold milk and slowly heated to boiling, oysters being removed for analysis at the times indicated. In Experiment No. 226 the milk was heated to boiling before the oysters were inserted.

	Experiment Number.	Number of Oysters tested.	Per Cent. of Samples giving Positive Tests.									
			Shell Water.			Intestine.			Mash.			
			Fermented.	B. Coli Present.	Streptococcus Present.	Fermented.	B. Coli Present.	Streptococcus Present.	Number of Oysters tested.	Fermented.	B. Coli Present.	Streptococcus Present.
Raw oysters,	225	10	100	80	90	80	20	60	10	100	70	90
In milk 7 minutes 80 degrees C.	225	10	-	-	-	50	20	20	-	-	-	-
In milk 16 minutes 100 degrees C.	225	10	-	-	-	0	0	0	-	-	-	-
After boiling 5 minutes,	225	10	-	-	-	30	0	0	-	-	-	-
After boiling 15 minutes,	225	10	-	-	-	0	0	0	-	-	-	-
Raw oysters,	243	10	100	70	10	10	10	0	10	90	70	0
In milk 19 minutes, 80 degrees C.	243	10	-	-	-	20	0	0	-	-	-	-
In milk 29 minutes, 100 degrees C.	243	10	-	-	-	0	0	0	-	-	-	-
After boiling 2 minutes,	243	10	-	-	-	0	0	0	-	-	-	-
After boiling 5 minutes,	243	10	-	-	-	10	0	0	-	-	-	-
Raw oysters,	226	10	100	80	90	80	20	60	10	100	70	90
Boiled 2 minutes,	226	10	-	-	-	20	0	10	-	-	-	-
Boiled 5 minutes,	226	10	-	-	-	10	0	0	-	-	-	-
Boiled 15 minutes,	226	10	-	-	-	0	0	0	-	-	-	-

Experiments Nos. 228, 229, 236 and 237. Fried Oysters.

Oysters were inoculated with B. coli by being placed over night in badly polluted salt water. After opening, the oysters were rolled in corn meal and fried for varying periods with salt pork.

			Per Cent. of Samples giving Positive Tests.									
			Shell Water.			Intestine.			Mash.			
	Experiment Number.	Number of Oysters tested.	Fermented.	B. Coli Present.	Streptococcus Present.	Fermented.	B. Coli Present.	Streptococcus Present.	Number of Oysters tested.	Fermented.	B. Coli Present.	Streptococcus Present.
Raw oysters, . . .	228	10	100	80	40	100	50	10	10	100	80	30
Fried 2 minutes, . . .	228	10	-	-	-	50	0	0	-	-	-	-
Fried 5 minutes, . . .	228	10	-	-	-	30	0	0	-	-	-	-
Fried 10 minutes, . . .	228	10	-	-	-	10	0	0	-	-	-	-
Fried 15 minutes, . . .	228	10	-	-	-	0	0	0	-	-	-	-
Raw oysters, . . .	229	10	100	80	40	100	50	10	10	100	80	30
Fried 10 minutes, . . .	229	10	-	-	-	20	0	0	-	-	-	-
Fried 15 minutes, . . .	229	10	-	-	-	10	0	0	-	-	-	-
Fried 20 minutes, . . .	229	10	-	-	-	0	0	0	-	-	-	-
Fried 30 minutes, . . .	229	10	-	-	-	0	0	0	-	-	-	-
Raw oysters, . . .	236	10	100	100	10	90	40	30	10	100	80	50
Fried 2 minutes, . . .	236	10	-	-	-	10	10	0	-	-	-	-
Fried 5 minutes, . . .	236	10	-	-	-	0	0	0	-	-	-	-
Fried 8 minutes, . . .	236	10	-	-	-	10	10	0	-	-	-	-
Raw oysters, . . .	237	10	100	100	10	90	40	30	10	100	80	50
Fried 2 minutes, . . .	237	10	-	-	-	0	0	0	-	-	-	-
Fried 5 minutes, . . .	237	10	-	-	-	0	0	0	-	-	-	-
Fried 8 minutes, . . .	237	10	-	-	-	0	0	0	-	-	-	-

Experiments Nos. 231, 234, 240 and 241. Escalloped Oysters.

Oysters were inoculated with B. coli by being placed over night in badly polluted salt water. After opening, the oysters were placed in a bowl with cracker crumbs: first a layer of oysters, then a layer of crumbs, more oysters, then more crumbs, etc., until the bowl was full. Milk was then poured in until the mixture was thoroughly saturated, and the bowl and contents were placed in a hot oven.

	Experiment Number.	Number of Oysters tested.	Per Cent. of Samples giving Positive Tests.									
			Shell Water.			Intestine.			Mash.			
			Fermented.	B. Coli Present.	Streptococcus Present.	Fermented.	B. Coli Present.	Streptococcus Present.	Number of Oysters tested.	Fermented.	B. Coli Present.	Streptococcus Present.
Raw oysters, ...	231	10	100	100	10	10	0	0	10	100	90	10
Baked 30 minutes, . .	231	10	–	–	–	0	0	0	–	–	–	–
Baked 60 minutes, . .	251	10	–	–	–	0	0	0	–	–	–	–
Baked 90 minutes, . .	231	10	–	–	–	0	0	0	–	–	–	–
Raw oysters, ...	234	10	100	40	90	90	30	30	10	100	60	30
Baked 15 minutes, . .	234	10	–	–	–	0	0	0	–	–	–	–
Baked 30 minutes, . .	234	10	–	–	–	0	0	0	–	–	–	–
Baked 45 miuutes, . .	234	10	–	–	–	0	0	0	–	–	–	–
Raw oysters, ...	240	10	100	90	100	30	10	20	10	100	80	100
Baked 15 minutes, . .	240	10	–	–	–	20	10	10	–	–	–	–
Baked 30 minutes, . .	240	10	–	–	–	0	0	0	–	–	–	–
Baked 45 minutes, . .	240	10	–	–	–	0	0	0	–	–	–	–
Raw oysters, ...	241	10	100	90	100	30	10	20	10	100	80	100
Baked 15 minutes, . .	241	10	–	–	–	10	0	0	–	–	–	–
Baked 30 minutes, . .	241	10	–	–	–	0	0	0	–	–	–	–
Baked 45 minutes, . .	241	10	–	–	–	0	0	0	–	–	–	–

Temperature of mixture after 15 minutes — 60 to 65 degrees C.
Temperatnre of mixture after 30 miuutes — 95 to 98 degrees C.
Temperature of mixture after 45 minutes — 98 to 100 degrees C.

Besides this experimental work upon the ordinary methods of cooking, inquiries were made at hotels, etc., in regard to this subject. The information obtained in this way was slight, but indicated that a very large percentage of both clams and oysters are served either raw, or cooked by one of the methods covered in this report. Other methods of cooking are, of course, employed, but the percentage of shellfish served in other ways is comparatively small. The object appears to be, in all instances, to cook both clams and oysters — and especially the latter — as little as possible, in order that the palatability of the shellfish may not be impaired.

Conclusions.

There is abundant proof at the present time that polluted shellfish are carriers of disease. The work covered by this report has been directed along lines such as would show the degree of pollution of

shellfish either collected by ourselves or bought in the market, the destruction of bacteria by digestion or by heat, and the immunity from danger that can be obtained by ordinary methods of cooking.

The evidence gathered in this work is fairly conclusive that B. coli and *Streptococcus* are not normal inhabitants of the shell water or body of either oysters or clams, and that their presence there must be considered proof of pollution. Of 88 samples of clams gathered from 11 polluted sources in the early part of this work, 25, or 28 per cent. only, contained bacteria of the colon type; of 44 samples obtained during the same period from 16 sources that may be considered non-polluted or but slightly polluted, none contained bacteria of the colon type. The same statements hold true in a general way in regard to the shell water of the samples from practically every source included in the above summary, although the shell water is more likely to contain sewage bacteria than is the shellfish itself.

It is also true that, of the large number of clams examined from many sources, the larger percentage was free from bacteria of the colon type; and the same statement holds true of the oysters examined, as shown by the tables presented. A number of lots of oysters were obtained which were free from bacteria of the type named, judging from the samples examined; but a number of lots were obtained of which a considerable percentage of the oysters contained B. coli and *Streptococcus,* judging from the oysters examined. These oysters must have been from polluted sources, or they were polluted in some manner after being gathered.

The work also shows that B. coli and the sewage *Streptococcus* can live upon or in the body of clams and oysters for many days when these shellfish are kept under market conditions; hence immunity from or destruction of pollution in this manner cannot be assured.

The cooking experiments with both clams and oysters show that some of the common methods of cooking cannot be depended upon to destroy the bacteria of the sewage type found in shellfish; that is, to do this, a degree of heat or a period of cooking is required in many instances that destroys or impairs the palatability of both oysters and clams. It is, of course, evident that neither should be eaten in the raw condition except from unpolluted and certified sources. It is also evident that, in order that all danger from bacterial pollution may be removed, the sources from which clams and oysters are gathered should be carefully protected from pollution, and that the shellfish from sources known to be polluted should not be allowed to be shipped to market.

In this work the writer has been ably assisted by Mr. Stephen DeM. Gage.

APPENDIX TO REPORT OF H. W. CLARK UPON LAWRENCE EXPERIMENT STATION STUDIES OF THE POLLUTION OF SHELLFISH.

During the work at Lawrence, various studies, besides those summarized in the foregoing report, were made, as follows: the pollution of the Newburyport clam flats was investigated, and more than 150 samples of clams from that area, together with many samples of water, were examined; many samples of shellfish from various portions of the coast were examined, and experiments upon the viability of B. coli in polluted sea water and polluted fresh water were carried out.

Studies of the Joppa Clam Flats, Newburyport.

The Newburyport clam flats are large in area, and extend along the south shore of the Merrimack River at Newburyport or the south shore of the harbor, and reach from the city limits to Plum Island. The flats become narrow at both ends, and at the upper end the main sewer of the city of Newburyport empties into the river, the mouth of this sewer extending but a few feet beyond the limit of low tide. Just below this sewer, a brook also empties into the river, and the water from this brook at times, and at certain stages of the tide, tends to cause the sewage to flow into the river and prevent it from coming over upon the near-by flats. This is of little influence, however, upon the general pollution of the flats.

Besides contamination from the Newburyport sewage, the waters of the sewage-polluted Merrimack River overflow these flats at high tide. For a considerable distance from the sewer outlet — in fact, several hundred feet — the flat is generally discolored by sewage deposits, the limit of noticeable deposit varying from time to time. The main portion of the flat, however, is clean in appearance. Clams are dug over the entire flat and to within a few feet of the sewer outlet, although by far the larger portion of the clams are dug in the two-thirds of the area farthest from the outlet.

In the collection of samples of clams from this area, a series of stations was first located, these stations extending from within 25 feet of the sewer outlet to a distance of about 8,300 feet from this outlet down river, and the stations were also located across the flats at right angles to the flow of the river. The stations were 72 in number, and from them 156 samples of clams were collected upon 7 different dates. The results of the examination of these samples are summarized in the following tables.

It will be noticed that, as shown by the presence of B. coli and *Streptococcus* in the shell water and intestine, a very large percentage of the clams tested were sewage-polluted, the largest percentage giving positive tests for B. coli being taken at a point between 3,000 and 4,000 feet from the sewer outlet. That a larger number of positive tests was not given when examining the clams taken from stations nearer this outlet, was undoubtedly due to the large number of other bacteria present which overgrew B. coli. The greatest percentage of positive tests for *Streptococcus* was given with the clams taken from the station nearest the sewer outlet.

Table showing Percentage of Positive Tests for B. Coli and the Sewage Streptococcus in the Shell Water and Intestines of Clams from the Newburyport Clam Flats.

Distance from Sewer Outlet (in Feet), between —	Shell Water.		Intestines.	
	B. Coli.	Streptococcus.	B. Coli.	Streptococcus.
0-100,	75	75	0	100
100-500,	55	16	11	74
500-1,000,	42	25	25	80
1,000-2,000,	41	52	28	70
2,000-3,000,	53	39	28	81
3,000-4,000,	100	40	40	100
4,000-5,000,	37	14	14	84
5,000-6,000,	58	29	29	86
6,000-7,000,	50	17	0	68
7,000-8,300,	37	37	12	87

Summary of Tests on Samples collected and forwarded to the Experiment Station previous to January, 1905.

The three following tables summarize the results of tests for B. coli in clams and sea water samples taken by the engineering department, or by myself or assistants, prior to January, 1905. In this summary the samples are grouped in three classes: from polluted areas, from areas free from pollution or only slightly polluted, and from areas open to suspicion. Classifying the samples in this way, it is found that, of the 88 samples of shellfish from polluted sources, 24 gave positive tests for bacteria of the colon type; and of the 87 samples of sea water from these sources, 29 gave positive tests for these organisms. Of the samples of shellfish from non-polluted sources, 44 in number, and of the samples of sea water from these sources, 37 in number, none gave evidence of the presence of these bac-

teria. Of the samples from sources possibly polluted, none of the 66 samples of clams examined gave positive tests for B. coli; but of the 32 samples of sea water 6 gave positive tests for bacteria of the colon type. The tables follow: —

TABLE NO. 1. — *Showing Results of Tests for B. Coli in Shellfish and Sea Water from Polluted Sources.*

Source.	Number of Samples.		Number of Samples giving Positive Tests.					
			Shellfish.				Sea Water.	
			Shell Water.		Intestine.			
	Shell-fish.	Sea Water.	Pre-sumptive Test.	Colon Type.	Pre-sumptive Test.	Colon Type.	Pre-sumptive Test.	Colon Type.
Boston harbor: —								
East Boston flats,	7	7	3	1	3	0	1	0
Long Island,	3	4	3	1	3	1	2	2
Squantum,	12	10	8	3	17	6	10	3
Charles River,	7	9	2	2	3	0	4	4
Charles River,	10	0	9	4	15	6	0	0
Fall River,	5	9	3	1	2	0	6	2
Marion,	5	0	0	0	3	3	0	0
Mystic River,[1]	10	10	1	0	9	0	0	0
New Bedford,	20	28	22	13	16	8	19	14
Newburyport,[2]	7	8	1	0	7	0	7	3
Salisbury,	2	2	0	0	2	0	3	1
	88	87	52	25	80	24	52	29

[1] Near sewer outlet. [2] Fox Island Creek and Lunch Rock.

TABLE NO. 2. — *Showing Results of Tests for B. Coli in Shellfish and Sea Water from probably Non-polluted Sources.*

Source.	Number of Samples.		Number of Samples giving Positive Tests.					
			Shellfish.				Sea Water.	
			Shell Water.		Intestine.			
	Shell-fish.	Sea Water.	Pre-sumptive Test.	Colon Type.	Pre-sumptive Test.	Colon Type.	Pre-sumptive Test.	Colon Type.
Cotuit,	2	0	0	0	0	0	0	0
Dighton: —								
Yacht Club beds,	1	1	0	0	0	0	0	0
Half-tide beds,	1	1	0	0	0	0	0	0
Freetown Island beds,	5	4	0	0	0	0	0	0
Ipswich,	12	13	0	0	6	0	0	0
Newbury,	5	4	0	0	2	0	0	0
Revere,	3	2	0	0	2	0	0	0
Somerset,	2	3	0	0	0	0	0	0
Wellfleet: —								
Duck Creek,	0	4	0	0	0	0	0	0
Great Bay,	2	0	0	0	0	0	0	0
Egg Island,	1	0	0	0	0	0	0	0
Flat Rock,	2	0	0	0	0	0	0	0
Indian Neck,	1	0	0	0	0	0	0	0
Billingsgate Point,	2	0	0	0	0	0	0	0
Weymouth: —								
Fore River,	2	2	0	0	0	0	0	0
Back River,	3	3	0	0	1	0	1	0
	44	37	0	0	11	0	1	0

TABLE NO. 3.— *Showing Results of Tests for B. Coli in Shellfish and Sea Water from Sources which are possibly Polluted.*

Source.	Number of Samples.		Number of Samples giving Positive Tests.					
			Shellfish.				Sea Water.	
			Shell Water.		Intestine.			
	Shellfish.	Sea Water.	Presumptive Test.	Colon Type.	Presumptive Test.	Colon Type.	Presumptive Test.	Colon Type.
Berkeley,	2	2	1	1	0	0	1	1
Duxbury: —								
Standish shore,	1	1	0	0	0	0	1	1
Mill Pond,	1	1	0	0	0	0	0	0
Powder Point,	1	1	0	0	0	0	1	1
Fairhaven: —								
Flats,	5	0	0	0	3	0	0	0
Dealer,	1	0	1	0	1	0	0	0
Gloucester,	4	4	3	1	3	0	5	1
Lynn,	6	6	0	0	5	0	1	1
New Bedford,	24	2	2	0	9	0	2	0
Quincy: —								
Location not known,	8	9	8	0	8	0	10	1
Quincy Bay,	3	3	0	0	3	0	0	0
Rock Island Cove,	2	2	0	0	2	0	0	0
Town River Bay,	1	1	0	0	1	0	0	0
Swansea,	7	0	1	1	0	0	0	0
	66	32	18	4	42	0	21	6

EXPERIMENTS ON THE VIABILITY OF B. COLI IN SALT AND FRESH WATER.

Two experiments were made on the viability of B. coli and on the change in the bacterial contents of water more or less polluted.

Experiment No. 125. — In this experiment, sea water from the shore of Plum Island was polluted with different amounts of sewage, varying from 10 per cent. of sewage to 50 per cent. of sewage by volume. The bottles containing this mixture of sea water and sewage were placed in the ice box at an average temperature of 41 degrees F., and tests for total bacteria and for B. coli were made from time to time. After the thirtieth day, the number of B. coli had become so low in the various samples that, instead of counting them, fermentation tests were made on one-hundredth of a cubic centimeter, one-tenth of a cubic centimeter and one cubic centimeter of the water; and the experiment was con-

tinued until B. coli was not found in any one-cubic-centimeter sample. A table following shows that B. coli was found in a sample from one bottle at the end of one hundred and sixty-six days, but none was found after this.

Experiment No. 144. — In this experiment, Lawrence tap water was polluted with sewage, the amount of sewage varying from 10 per cent. to 50 per cent. by volume. The bottles containing the samples were kept in the ice box at an average temperature of 41 degrees F., and tests for total bacteria and for B. coli were made from time to time. After the fifteenth day, the B. coli tests were made by the fermentation method, testing volumes of water varying from one-twentieth of a cubic centimeter to 10 cubic centimeters; and the experiment was continued until all of the samples showed the absence of B. coli in 10 cubic centimeter volumes, which occurred at the end of the sixty-second day.

Experiment No. 125. Change in the Numbers of Bacteria in Sea Water polluted with Different Amounts of Sewage. Experiment started Nov. 4, 1903.

Elapsed Time.	Amount of Sewage.				
	10 Per Cent.	**20** Per Cent.	**30** Per Cent.	**40** Per Cent.	**50** Per Cent.
Start,	105,000	335,000	475,000	630,000	700,000
1 day,	105,000	355,000	781,000	1,155,000	3,100,000
2 days,	200,000	1,597,000	4,899,000	4,475,000	7,455,000
3 days,	958,500	3,408,000	5,680,000	8,520,000	7,990,000
4 days,	1,203,000	4,044,000	10,508,000	12,780,000	12,780,000
5 days,	3,905,000	2,500,000	8,660,000	11,720,000	16,000,000
6 days,	2,100,000	5,250,000	11,000,000	21,000,000	27,500,000
7 days,	650,000	4,350,000	7,300,000	17,000,000	23,000,000
8 days,	1,250,000	5,050,000	19,000,000	17,000,000	29,250,000
9 days,	800,000	3,650,000	9,250,000	10,750,000	5,000,000
10 days,	820,000	3,200,000	2,250,000	4,750,000	2,000,000
11 days,	1,800,000	350,000	500,000	2,000,000	1,500,000
12 days,	900,000	350,000	1,250,000	1,250,000	1,500,000
13 days,	320,000	210,000	450,000	1,200,000	1,100,000
14 days,	102,500	132,000	280,000	1,200,000	1,100,000
15 days,	51,000	58,000	150,000	600,000	1,300,000
16 days,	52,000	75,000	92,000	480,000	630,000
17 days,	34,000	88,800	128,000	170,000	400,000
18 days,	23,700	43,300	70,500	125,500	161,500
19 days,	33,200	61,000	140,000	166,000	126,000
20 days,	23,000	37,100	170,000	146,000	166,000
21 days,	35,500	69,000	140,000	340,000	160,000
22 days,	43,500	50,000	160,000	300,000	150,000
23 days,	25,000	39,000	245,000	242,000	160,000
24 days,	31,500	30,000	125,000	165,000	130,000
26 days,	36,000	43,500	167,500	150,500	160,000
28 days,	37,500	32,500	116,500	132,500	62,500
30 days,	27,500	36,000	150,000	100,000	95,000
33 days,	77,500	48,000	95,000	95,000	87,500
36 days,	26,000	37,500	150,000	114,000	66,000
42 days,	18,000	33,000	62,000	52,000	63,000
48 days,	17,000	26,500	170,000	50,000	20,000
56 days,	18,000	22,500	37,500	155,000	41,500
63 days,	6,500	24,500	55,500	41,500	25,500
70 days,	5,000	18,500	39,500	31,000	35,000
77 days,	5,500	26,000	32,000	24,000	20,000
84 days,	3,500	18,800	37,300	25,800	35,400
92 days,	4,000	32,000	60,000	71,000	39,000
105 days,	7,500	12,300	37,500	32,500	27,000
119 days,	1,300	4,900	19,000	9,500	18,000
133 days,	–	–	–	23,500	10,000
152 days,	–	–	–	18,500	35,000
166 days,	–	–	–	32,000	28,000
180 days,	–	–	–	23,200	17,800

Experiment No. 125. B. Coli in Sea Water polluted with Different Amounts of Sewage.

Elapsed Time.	Amount of Sewage.				
	10 Per Cent.	**20** Per Cent.	**30** Per Cent.	**40** Per Cent.	**50** Per Cent.
Start,	4,000	31,000	38,000	25,000	75,000
1 day,	6,200	25,000	67,500	130,000	145,000
2 days,	14,000	30,000	70,000	127,500	150,000
3 days,	30,000	40,000	90,000	200,000	300,000
4 days,	22,500	50,000	49,000	225,000	262,500
5 days,	44,000	17,000	90,000	210,000	225,000
6 days,	26,500	87,500	145,000	190,000	50,000
7 days,	50,000	75,000	190,000	300,000	375,000
8 days,	30,000	35,000	130,000	95,000	125,000
9 days,	19,000	30,000	55,000	70,000	17,500
10 days,	32,500	59,000	142,500	900,000	59,000
11 days,	17,800	42,000	21,500	35,000	53,000
12 days,	18,500	3,500	17,500	15,000	21,500
13 days,	5,500	5,300	8,500	22,500	21,000
14 days,	1,400	2,000	12,000	3,300	34,000
15 days,	3,000	1,000	1,100	18,000	20,000
16 days,	1,300	3,800	12,000	15,000	18,000
17 days,	2,100	500	1,500	3,500	9,000
18 days,	2,000	250	1,000	12,000	16,000
19 days,	1,100	1,500	3,000	7,500	10,000
20 days,	1,100	1,350	2,800	4,000	13,000
21 days,	1,000	1,450	1,500	2,100	13,000
22 days,	800	450	700	800	3,500
23 days,	500	150	500	500	4,000
24 days,	275	6	124	100	5,800
26 days,	280	176	10	30	300
28 days,	22	30	18	13	5
30 days,[1]	0.1=+	0.1=+	1=+	0.1=+	0.1=+
33 days,[1]	0.1=+	0.1=+	1=+	1=+	1=0
36 days,[1]	0.1=+	0.1=+	1=+	1=0	1=+
42 days,[1]	0.1=+	0.1=+	1=+	1=+	1=+
48 days,[1]	1=+	0.1=+	1=+	1=0	1=+
56 days,[1]	0.1=+	1=+	1=+	0.1=+	1=0
63 days,[1]	1=+	1=+	1=+	1=+	1=0
70 days,[1]	1=+	1=+	1=+	1=0	1=+
77 days,[1]	1=+	1=+	1=+	1=0	1=+
84 days,[1]	1=+	1=+	1=0	1=0	1=+
92 days,[1]	1=0	1=+	1=+	1=+	1=0
105 days,[1]	1=0	1=+	1=0	1=0	1=0
119 days,[1]	1=0	1=0	1=0	1=+	1=+
133 days,[1]	1=0	1=0	1=0	1=0	1=0
152 days,[1]	1=0	1=0	1=0	1=+	1=+
166 days,[1]	1=0	1=0	1=0	1=0	1=+
180 days,[1]	1=0	1=0	1=0	1=0	1=0

[1] Tests made by fermentation method in different volumes. Plus results shown indicate the smallest volume in which B. coli was found.

Experiment No. 144. Change in the Numbers of Bacteria in City Water polluted with Different Amounts of Sewage. Feb. 16, 1904.

Elapsed Time.	Amount of Sewage.				
	10 Per Cent.	20 Per Cent.	30 Per Cent.	40 Per Cent.	50 Per Cent.
Start,	122,500	350,000	420,000	480,000	680,000
1 day,	86,500	150,000	275,000	480,000	1,180,000
2 days,	122,500	380,000	1,000,000	1,300,000	3,220,000
3 days,	300,000	1,050,000	3,600,000	2,940,000	5,200,000
4 days,	860,000	2,200,000	4,100,000	2,750,000	5,800,000
7 days,	4,800,000	5,600,000	6,300,000	7,000,000	6,000,000
8 days,	3,010,000	2,690,000	3,050,000	4,900,000	5,200,000
9 days,	950,000	1,500,000	1,900,000	3,900,000	4,400,000
10 days,	700,000	700,000	1,000,000	2,750,000	3,650,000
11 days,	50,000	150,000	500,000	750,000	2,500,000
13 days,	127,000	220,000	480,000	1,400,000	3,600,000
14 days,	85,000	140,000	270,000	520,000	900,000
15 days,	51,500	111,000	150,000	430,000	630,000
20 days,	70,000	140,000	175,000	710,000	1,440,000
23 days,	71,000	175,000	160,000	350,000	700,000
30 days,	–	80,000	40,000	150,000	110,000
36 days,	76,500	127,500	53,000	103,000	87,500
48 days,	50,000	48,000	105,000	190,000	140,000
62 days,	28,000	47,500	135,000	137,000	139,000
76 days,	35,000	85,000	210,000	220,000	116,500
92 days,	29,000	43,600	137,500	150,000	82,500
126 days,	10,000	13,500	17,500	2,000	11,500

Experiment No. 144. B. Coli in City Water polluted with Different Amounts of Sewage.

Elapsed Time.	Amount of Sewage.				
	10 Per Cent.	20 Per Cent.	30 Per Cent.	40 Per Cent.	50 Per Cent.
Start,	7,000	11,200	25,500	50,000	50,000
1 day,	1,300	2,000	9,500	2,000	62,000
2 days,	2,650	2,500	6,000	10,000	45,000
3 days,	1,250	1,500	3,400	4,800	34,000
4 days,	0	350	1,800	3,200	12,500
7 days,	–	300	1,700	1,400	10,500
8 days,	70	40	350	900	7,000
9 days,	120	120	500	750	3,000
10 days,	18	140	240	720	2,500
11 days,	6	132	350	260	1,900
13 days,	4	10	35	40	500
14 days,	3	3	40	40	100
15 days,[1]	1 = +	1 = +	10	15	150
20 days,[1]	10 = +	10 = +	10 = +	10 = +	.05 = +
23 days,[1]	1 = +	10 = +	.1 = +	.1 = +	.01 = +
30 days,[1]	1 = +	10 = 0	1 = +	1 = +	.05 = +
36 days,[1]	10 = 0	10 = 0	10 = +	10 = +	1 = +
48 days,[1]	10 = 0	10 = 0	10 = 0	10 = 0	.1 = +
62 days,[1]	10 = 0	10 = 0	10 = 0	10 = 0	1 = +
76 days,[1]	10 = 0	10 = 0	10 = 0	10 = 0	10 = 0
92 days,[1]	10 = 0	10 = 0	10 = 0	10 = 0	10 = 0
126 days,[1]	10 = 0	10 = 0	10 = 0	10 = 0	10 = 0

[1] Tests made by fermentation method in different volumes. Plus results shown indicate the smallest volume in which B. coli was found.

Extracts from the Fourth Report of the Royal Commission on Sewage Disposal of Great Britain. Pollution of Tidal Waters, with Special Reference to the Contamination of Shellfish.

It will be seen from the evidence of Dr. Klein that his test for oysters was based on the view that the normal oyster does not harbor within its shell or within its body Bacillus coli communis or other coli closely allied to it.

We therefore thought it desirable to examine the premise on which Dr. Klein's method is based, namely, the absence of B. coli communis or other B. coli closely allied to it from the normal oyster; and accordingly we instructed our bacteriologist, Dr. Houston, to examine a large number, on the one hand, of oysters from some of the purest waters in which oysters are grown or fattened in this country, and, on the other hand, of oysters from layings, etc , obviously liable to pollution.

A full account of this work is given in Dr Houston's report. His investigation has been carried out in the most careful manner, and over one thousand oysters have been examined. The results show that nearly all the oysters so examined, from whatever laying they were taken, contained Bacillus coli communis or other B. coli closely allied to it.

The result of Dr. Houston's examination, to which we wish to call special attention, is that, as a rule, taking in each case the whole oyster, a very much smaller number of B. coli or coli-like microbes is found in oysters stored in pure waters than in oysters stored in polluted waters.

As regards deep-sea oysters the results are not quite decisive, but point strongly to the conclusion that not only typical B. coli but even coli-like microbes are absent from them Having regard to the results of our examination of other oysters, we doubt if, in judging whether shellfish are fit for human consumption or not, much weight can be attached to a mere statement that in a certain proportion of oysters of a batch the presence of Bacillus coli communis or other B. coli closely allied to it was noted.

Thirty-four samples of deep-sea water were collected on the northwest coast of Scotland, within sight of land, though remote from all possibility of contamination, at separate spots along a line more than one hundred miles in length. None of these samples contained any spores of B. enteritidis sporogenes in 10 c. c., and no coli-like microbes of any sort, even when using for cultural purposes 100 c. c. of water.

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

Prior to the year 1882, the laws relating to the inspection and sale of foods in Massachusetts included one concerning milk and one concerning vinegar (both of which were very imperfectly enforced), and a number of special laws of no practical importance, which, so far as can be ascertained, were not enforced at all. The Legislature of the year mentioned enacted a general law entitled "An Act relating to the adulteration of food and drugs," which, after setting forth what should be held to constitute adulteration, and defining the terms "food" and "drug," provided that the State Board of Health, Lunacy and Charity should appoint inspectors and analysts; should make all necessary investigations and inquiries in reference to the food and drug supply; should make rules and regulations concerning the collection and examination of samples; and should establish standards not specifically provided. For carrying out the provisions of the act the sum of $3,000 was appropriated. The law was approved on May 28, and went into effect three months later; whereupon the Board appointed an analyst of foods and an analyst of drugs, who were directed to collect and examine samples, with such assistance as they might require, the appropriation being not large enough to permit the employment of regular inspectors.

The investigations made in the two fields showed that the market was in a most deplorable condition. In spite of the fact that the law relating to the inspection and sale of milk had been in existence for many years, the milk supply was found to be especially poor, adulteration being almost universally practised in the cities and large towns. So great was this evil that in the following year, 1883, the Legislature amended the act by increasing the appropriation to $5,000, with the proviso that two-fifths of the whole should be expended in enforcing the milk law. Accordingly, two additional analysts were appointed, whose sole duty it was to look after this part of the work. The first report of the analyst for the eastern portion of the State showed that no less than 77.45 per cent. of all samples examined failed to conform to the requirements of the statute. In Boston the percentage of adulterated samples was 86.78; in East Boston it was 80; in South Boston it was 93.75; in Charlestown it was 92.86; in Cambridge, 83.33.

At that time, and long prior thereto, the local inspectors did little more than carry out the provision of the law that they should keep an

office and issue licenses. In most of the cities the duty of serving as inspector devolved upon the city marshal or other salaried official, who received therefor no extra compensation, or at most a trifling sum, like $25.

Owing to the conditions found by the several analysts to exist in their different fields, the Legislature of 1884 made further amendments of the food and drug act, the most important of which increased the appropriation to $10,000, whereof not less than $6,000 should be devoted to the enforcement of the laws relating to milk and milk products. This enabled the Board to appoint regular inspectors, who, by law, were clothed with all the authority given to local inspectors.

The general law relating to food and drugs was not materially amended between 1884 and 1901; but in the latter year it was strengthened by the addition of a section prohibiting the use of certain preservatives, unless their presence and percentage are clearly set forth on the label in letters of a certain size, and by further legislation regulating the manner in which so-called *compounds* shall be labelled so that the purchaser may know their percentage composition. The amendment relative to the use of preservatives settled a much-vexed question; for, while the law prohibited the sale of foods containing ingredients injurious to the health of the consumer, authorities are by no means in agreement as to whether certain of the substances employed as preservatives exert an injurious influence on the system. The amendment waives the question, and leaves it to the consumer to decide whether he cares to assume the risk; but the vendor must acquaint him of the fact that the product is chemically preserved.

The sum placed at the disposal of the State Board of Health, which has had charge of the administration of the general law since its re-establishment as a separate Board in 1886, has been increased from time to time to $12,500, which is its present annual appropriation for this branch of its work.

The laws relating to the inspection and sale of milk, butter and oleomargarine have been amended from time to time, as occasion demonstrated a need of change. The standard requirement as to total solids of milk has been lowered from 13 to 12 per cent. for the time from April 1 to September 30; a standard for milk fat has been established, in order to prevent the removal of cream and admixture of condensed skimmed milk for the purpose of restoring the percentage of total solids; and the penalty for a first offence of possession or sale of milk not of standard quality has been reduced. But the penalty for the sale of skimmed milk not properly marked or of milk containing added foreign matter has been allowed to stand.

In consequence of fraudulent practices in the sale of oleomargarine, the law relating thereto has been amended a number of times, beginning in 1885; and at the present time, on account of national and State legislation, but little of that product is to be found on the market, and that in an uncolored form. The most stringent laws relating to oleomargarine were passed by the Legislature of 1891. These laws were contested even to the Supreme Court of the United States, which handed down a decision favorable to the State, and established their constitutionality. Later, the Legislature directed its attention to the substance known as "renovated" or "process" butter, and enacted a law, still in force, providing for its proper marking, so that it may not be sold as ordinary butter.

As stated above, the condition of the market when the work of inspection was begun was anything but creditable, especially with regard to the milk supply, which seemed to be hopelessly bad. The work was at first one of investigation and warning. Dealers whose goods were found to be impure were served with notices calling the facts to their attention, and warning them of the danger of prosecution. No cases were brought into court until the closing month of 1883. In 1884, 48 cases were brought, mainly for the sale of adulterated milk, and these exerted much influence. Later, as the work progressed, stricter measures were adopted. The system of warning retailers had its effect upon wholesalers, and soon many brands of adulterated goods were driven from the market; but many remained. From the beginning until the present time the object has been to conserve the interests of the public with justice to all concerned.

During the first eight years of the law the analysis of samples was conducted by the analysts of the Board in their own laboratories; but in the year 1891 most of the work was placed in charge of one chemist, in a small laboratory established by the Board in an office building, where it was conducted until the present laboratory in the State House was ready for occupancy, in 1895. The three chemists now employed are supplied with samples by three inspectors, who visit all parts of the State and conduct all proceedings in the lower courts. By a rule of the Board, the supervision of the work is delegated to the secretary, who directs the inspectors where samples shall be collected and what prosecutions shall be made.

The Legislature of 1905 passed two acts relative to food and drugs: one, chapter 236, amending section 24 of chapter 75, Revised Laws, by lowering the minimum penalty from $100 to $25, there being a general feeling among the judges of the district courts that the former penalty was in most instances excessive; and the other, chapter 220, dealing with the sale of wood alcohol and of food and drugs for internal use which may contain that substance. This act is as follows: —

AN ACT RELATIVE TO WOOD ALCOHOL.

Be it enacted, etc., as follows:

SECTION 1. Whoever, himself or by his servant or agent, or as the servant or agent of any other person, sells, exchanges or delivers any wood alcohol, otherwise known as methyl alcohol, shall affix to the vessel containing the same and shall deliver therewith a label bearing the words "Wood Alcohol, Poison", in black letters of uncondensed Gothic type not less than one fourth of an inch in height. Whoever violates the provisions of this section shall pay a fine of not less than fifty dollars nor more than two hundred dollars.

SECTION 2. Whoever, himself or by his servant or agent, or as the servant or agent of any other person, sells, exchanges or delivers, or has in his possession with intent to sell, exchange or deliver, any article of food or drink, or any drug intended for internal use, containing any wood alcohol, otherwise known as methyl alcohol, shall be punished by a fine of not less than two hundred dollars or by imprisonment for not more than thirty days, or by both such fine and imprisonment. [*Approved March 27, 1905.*

Shortly after taking effect, its provisions were enforced against several employees of a Connecticut house with branches in various cities of the Commonwealth, the offences charged being the sale of flavoring extracts made with wood alcohol.

In the accompanying report of the analyst will be found a detailed account of the examination of samples of food and drugs purchased by the inspectors during the year.

The Board is required, under the provisions of the statutes, to report annually to the General Court the number of prosecutions made, and an itemized account of the money expended in carrying out the provisions of the law. (Chapter 75, section 7, Revised Laws.) This report has been made annually to the General Court in January since 1884.

A general summary of the work of the Board in this direction is also presented in the annual report of each year.

In addition to the foregoing, the Board is required, by chapter 272 of the Acts of 1902, to publish as often "as once each month in the official publication of the board, . . . a certificate of the examination or analysis made by authority of the board during the preceding month of any article of food manufactured or offered for sale in the Commonwealth, which is adulterated within the meaning of chapter seventy-five of the Revised Laws; and the board shall also cause to be published, with such certificate of examination, a statement of the trade-mark, brand-mark, or name, with the name and place of business of the manufacturer, which appear upon the package or box containing such adulterated article, or with the name and place of business of the wholesale dealer of whom the goods were obtained."

The official publication referred to in the foregoing statute is the weekly bulletin of the Board, which has been published continuously during the past twenty years, and distributed principally to the health authorities of the cities and towns.

The following persons comprised the force employed by the Board in this department at the close of the year: —

ALBERT E. LEACH,	*Analyst.*
HERMANN C. LYTHGOE,	*Assistant Analyst.*
CHARLES H. HICKEY,	*Assistant Analyst.*
JOHN H. TERRY,	*Inspector.*
HORACE T. DAVIS,	*Inspector.*
ALVORD H. ROSE,	*Inspector.*

The number of samples of food and drugs examined during the year is shown in the accompanying table, together with a summary of the work done since the beginning of this line of work in 1882: —

FOOD AND DRUG INSPECTION (1882–1905).

SUMMARY.	YEARS. 1905.	TOTAL 1882-1905.
Number of samples of milk examined,	3,164	90,468
Number of samples above standard,	1,841	57,434
Number of samples below standard,	1,323	33,034
Number of samples of other kinds of food examined (not milk),	2,176	56,985
Number of samples of good quality,	1,634	46,503
Number of samples adulterated, as defined by the statutes,	542	10,482
Number of samples of drugs examined,	764	15,989
Number of samples of good quality,	538	9,846
Number of samples adulterated, as defined by the statutes,	226	6,161
Total examinations of food and drugs,	6,104	163,460
Total samples of good quality,	4,013	113,783
Total samples not conforming to the statutes,	2,091	49,677

It is impossible to draw any conclusions as to the extent of the practice of adulteration of food and drugs from the returns of the laboratory, since the aim of the inspectors is not to secure a large number of samples to submit to the analyst, but to seek out, so far as possible, those likely to be adulterated. Therefore, the percentage of samples found to be bad is far above what would be the case were discrimination and discretion not exercised. Unfortunately, it suits the purposes of certain over-zealous advocates of national food legislation to publish statements that, in spite of the excellence of the Massachusetts laws and the strictness with which

they are enforced, the food supply of the State, as shown by official returns, is adulterated to the extent of 25 to 30 per cent., — a statement that is grossly untrue.

During the year covered by this report the number of prosecutions for violation of the food laws was 313. The details are presented below. The amount paid in fines was $8,486, which sum brings the total to $50,914.48.

Prosecutions.

The following table presents the statistics relative to the prosecutions which have been conducted under the food and drug acts since the beginning of work in 1883 (Revised Laws, chapter 75, sections 16 to 27): —

Number of Complaints entered in Court.

Year.	Food and Other Articles (not including Milk).	Drugs.	Milk.	Total.	Convictions.	Fines imposed.
1883,	-	5	4	9	8	-[1]
1884,	2	1	45	48	44	-[1]
1885,[2]	50	1	68	119	103	-[1]
1886,[3]	10	-	10	20	19	-[1]
1887,	30	-	34	64	60	-[1]
1888,	22	-	43	65	61	$2,042 00
1889,	74	-	66	140	124	3,889 00
1890,	78	-	24	102	96	3,919 00
1891,	96	5	49	150	135	2,668 00
1892,	52	12	72	136	123	3,661 70
1893,	26	3	67	96	92	2,476 00
1894,	14	-	76	90	77	2,625 00
1895,	13	11	68	92	86	2,895 30
1896,	7	-	68	75	74	2,812 20
1897,	13	1	51	65	64	2,756 60
1898,	10	-	54	64	62	2,060 98
1899,	19	2	26	47	45	1,432 66
1900,	45	5	44	94	89	1,890 70
1901,	30	-	65	95	90	1,874 70
1902,	25	3	48	76	74	2,617 98
1903,	34	1	44	79	70	1,297 66
1904,	6	6	50	62	57	1,509 00
1905,	209	27	77	313	259[4]	8,486 00
	865	83	1,153	2,101	1,912	$50,914 48

[1] No record kept. [2] To May 1, 1886. [3] Four months only. [4] 24 cases pending.

The following table shows the nature of the offences complained of, the names of the defendants, the places where the offences were committed, the dates of trial or indictment, and the result of each case: —

For Sale of Milk not of Good Standard Quality.

Name.	Place.	Percentage of Total Solids.	Date.	Result.
John Godding,	Ashburnham,	–	July 3, 1905,	Conviction.
Elof. Erlandson,	Ashland,	11.16	Oct. 20, 1904,	Conviction.
Clarence H. Stowell,	Attleborough,	11.52	Feb. 17, 1905,	Conviction.
Patrick H. Martin,	Beverly,	10.26	Jan. 12, 1905,	Conviction.
Walter E. Dickerman,	Brockton,	11.05 [1]	Dec. 17, 1904,	Conviction.
Christopher Johnson,	Burlington,	11.30	Feb. 3, 1905,	Conviction.
Dwight M. Aldrich,	Charlton,	10.63	Oct. 18, 1904,	Conviction.
M. Goldman,	Chelsea,	11.47	Nov. 23, 1904,	Conviction.
M. Goldman,	Chelsea,	11.40	Nov. 23, 1904,	Conviction.
James A. Galvin,	Colrain,	7.94 [1]	May 12, 1905,	Conviction.
James A. Galvin,	Colrain,	4.69 [2]	May 12, 1905,	Conviction.
George W. Warner,	Colrain,	7.58 [1]	May 12, 1905,	Conviction.
George W. Warner,	Colrain,	7.32 [1]	May 12, 1905,	Conviction.
Richard Binnall,	Dover,	10.38	Oct. 27, 1904,	Conviction.
George N. Atwood,	Fall River,	11.60	June 29, 1905,	Conviction.
Manuel Furtado,	Fall River,	11.32	June 29, 1905,	Conviction.
H. C. Hambly,	Fall River,	9.89	June 29, 1905,	Conviction.
Uldric Lasselle,	Fall River,	10.91	June 29, 1905,	Conviction.
Edward S. Wright,	Fall River,	10.06 [1]	June 30, 1905,	Conviction.
Carl Klingbury,	Fitchburg,	11.34	June 13, 1905,	Conviction.
Elihu B. Andrews,	Gloucester,	11.30	Aug. 11, 1905,	Conviction.
Manuel F. Arvilla,	Gloucester,	11.34	Oct. 21, 1904,	Conviction.
John Geary,	Gloucester,	11.08	Aug. 11, 1905,	Conviction.
John Kerr,	Gloucester,	11.56	Oct. 21, 1904,	*Nol. pros'd.*
Henry W. Lane,	Gloucester,	10.78	May 15, 1905,	Conviction.
Hector D. Macdonald,	Gloucester,	11.73	Mar. 14, 1905,	Conviction.
Thomas McDougal,	Gloucester,	11.39	Aug. 11, 1905,	Conviction.
Manuel P. Madruga,	Gloucester,	9.56	Oct. 21, 1904,	Conviction.
Wm. F. Marshall,	Gloucester,	10.31	Sept. 30, 1905,	Conviction.
Charles F. Roberts,	Gloucester,	11.22	Mar. 14, 1905,	Conviction.
Frank W. Story,	Gloucester,	10.68	Oct. 21, 1904,	Conviction.
Ernest R. Houghton,	Grafton,	9.76	Sept. 28, 1905,	Conviction.

[1] Addition of water alleged in complaint.
[2] Addition of water and removal of cream alleged in complaint.

For Sale of Milk not of Good Standard Quality — Concluded.

Name.	Place.	Percentage of Total Solids.	Date.	Result.
Asa Burnham,	Holliston,	10.53 [1]	Apr. 22, 1905,	Conviction.
Asa Burnham,	Holliston,	10.53	Apr. 22, 1905,	Conviction.
Alfred Authier,	Holyoke,	10.87	Apr. 28, 1905,	Conviction.
Wallace J. Lothrop,	Ipswich,	10.23 [1]	Jan. 7, 1905,	Conviction.
Nelson C. Clermont,	Lowell,	11.63	Nov. 29, 1904,	Conviction.
Fred W. Crooker,	Lowell,	11.44	Nov. 29, 1904,	Conviction.
James Kousoulas,	Lowell,	11.85	Nov. 29, 1904,	Conviction.
Clarence Mahoney,	Lowell,	11.20	Feb. 16, 1905,	Conviction.
Leude Tousignant,	Lowell,	10.51	Jan. 11, 1905,	Acquittal.
George F. Crane,	Malden,	11.20	Mar. 23, 1905,	Conviction.
George E. Elwell,	Malden,	11.60	Mar. 20, 1905,	Conviction.
George Cooke,	Millis,	9.78 [1]	Dec. 29, 1904,	Conviction.
Benj. F. Brownell,	New Bedford,	11.29	Sept. 8, 1905,	Conviction.
Wm. L. Chadwick,	New Bedford,	11.36	Sept. 8, 1905,	Conviction.
George T. Parker,	New Bedford,	11.42	Sept. 8, 1905,	Conviction.
Wm. H. Freeman,	North Adams,	11.25	July 28, 1905,	Conviction.
Philip R. Howes,	Provincetown,	9.49	Sept. 13, 1905,	Conviction.
Albert E. Ayer,	Reading,	11.43	July 1, 1905,	Conviction.
Julius Bells,	Salem,	11.49	Jan. 10, 1905,	Conviction.
Stefan Bik,	Salem,	9.40	Jan. 10, 1905,	Conviction.
Jonathan D. Kelley,	Salem,	11.49	Feb. 11, 1905,	Conviction.
William H. Tobin,	Salem,	11.49	Jan. 10, 1905,	Conviction.
Walter M. Fay,	Southborough,	11.33	Dec. 3, 1904,	Conviction.
Joseph Michaud,	Swansea,	10.86	Dec. 28, 1904,	Conviction.
Harry R. Isham,	Warren,	10.00	June 1, 1905,	Conviction.
James White,	Warren,	10.76 [1]	June 1, 1905,	Acquittal.
Alden D. Wellington,	Wayland,	9.99	July 7, 1905,	Conviction.
Philip H. Doherty,	Woburn,	10.68	July 1, 1905,	Acquittal.
John C. Finnegan,	Woburn,	10.96	July 7, 1905,	Conviction.
Noe A. Brule,	Worcester,	11.63	Mar. 7, 1905,	Conviction.
John Coffee,	Worcester,	11.70	Mar. 20, 1905,	Conviction.
George E. Cone,	Worcester,	11.88	Mar. 15, 1905,	Conviction.
Nathan Lurier,	Worcester,	11.40	Mar. 20, 1905,	Conviction.
Theodore A. Small,	Worcester,	11.57	April 6, 1905,	Conviction.
Peter Trainor,	Worcester,	10.87	Mar. 15, 1905,	Conviction.

[1] Addition of water alleged in complaint.

For Sale of Milk containing Added Foreign Matter.

Name.	Place.	Adulterant.	Date.	Result.
Patrick H. Martin, . .	Beverly, . .	Coloring matter, .	Jan. 12, 1905,	Conviction.
John L. Babson, . .	Gloucester, . .	Coloring matter, .	Aug. 11, 1905,	Conviction.
John Perry, . . .	Gloucester, . .	Coloring matter, .	Oct. 21, 1904,	Conviction.
Annie E. Stevens, . .	Gloucester, . .	Coloring matter, .	Aug. 11, 1905,	Conviction.
Leude Tousignant, . .	Lowell, . .	Coloring matter, .	Jan. 11, 1905,	Conviction.
Edward S. Wright, . .	Fall River, . .	Formaldehyde, .	June 30, 1905,	Conviction.

For Obstruction of Inspector.

Name.	Place.	Date.	Result.
John Kerr, ...	Gloucester, .	Oct. 21, 1904,	Conviction.

For Sale of Adulterated Cream.

Name.	Place.	Adulterant.	Date.	Result.
Leslie C. Allen, . . .	Brockton, . .	Calcium sucrate, .	Feb. 9, 1905,	Conviction.
Jas. L. Humphrey, Jr., .	New Bedford, .	Boric acid, . .	Sept. 8, 1905,	Conviction.

For Sale of Unmarked Renovated Butter.

Name.	Place.	Date.	Result.
Charles F. Giles, ...	Somerville, .	Feb. 14, 1905,	Conviction.

For Sale of Adulterated Foods Other than Milk and Milk Products.

Hamburg Steak.

Name.	Place.	Adulterant.	Date.	Result.
Arthur H. Atwood, . .	Boston, . .	Sodium sulphite, .	Jan. 19, 1905,	Conviction.
Wm. H. Bezanson, . .	Boston, . .	Sodium sulphite, .	Jan. 19, 1905,	Conviction.
Wm. T. Crowther, . .	Boston, . .	Sodium sulphite, .	Jan. 19, 1905,	Conviction.
Frank M. Kimball, . .	Boston, . .	Sodium sulphite, .	Mar. 6, 1905,	Conviction.
Herbert S. Kingman, .	Boston, . .	Sodium sulphite, .	Jan. 19, 1905,	Conviction.
George H. Thwing, . .	Boston, . .	Sodium sulphite, .	Jan. 19, 1905,	Conviction.

For Sale of Adulterated Foods Other than Milk and Milk Products — Continued.

HAMBURG STEAK — *Concluded.*

Name.	Place.	Adulterant.	Date.	Result.
Charles W. Warren,	Boston,	Sodium sulphite,	Jan. 19, 1905,	Conviction.
John F. McGowan,	Cambridge,	Sodium sulphite,	Mar. 18, 1905,	Conviction.
Edgar E. McLaughlin,	Cambridge,	Sodium sulphite,	Mar. 18, 1905,	Conviction.
William A. Smith,	Cambridge,	Sodium sulphite,	Mar. 18, 1905,	Conviction.
Alfred H. Barlow,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
Joseph O. Brodeur,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
Wm. F. Gallagher,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
Archibald J. Keith,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
George R. Myers,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
Charles M. Ouimet,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
Samuel P. Pike,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
John F. Saunders,	Lowell,	Sodium sulphite,	Mar. 4, 1905,	Conviction.
Frank Torsney,	Peabody,	Sodium sulphite,	Feb. 25, 1905,	Acquittal.
Samuel H. Ware,	Peabody,	Sodium sulphite,	Feb. 25, 1905,	Conviction.
Isidore L'Heureux,	Salem,	Sodium sulphite,	Mar. 30, 1905,	Conviction.
Martin McDonald,	Salem,	Sodium sulphite,	Mar. 30, 1905,	Conviction.
Fayette A. Amidon,	Worcester,	Sodium sulphite,	May 16, 1905,	Conviction.

FRANKFORT SAUSAGE.

Omer G. Thompson,	Boston,	Boric acid,	Apr. 25, 1905,	Conviction.
Manuel Vreiro,	Cambridge,	Boric acid,	May 26, 1905,	Conviction.

OYSTERS.

Wm. M. Armstrong,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
David Atwood,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
Wm. C. Atwood,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
Charles A. Bacon,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
Alfred S. Higgins,	Boston,	Boric acid,	May 24, 1905,	Conviction.
R. R. Higgins Company,	Boston,	Boric acid,	June 14, 1905,	Conviction.
Benj. M. Johnson,	Boston,	Boric acid,	Apr. 26, 1905,	– [1]
Edward B. Newton,	Boston,	Boric acid,	Apr. 18, 1905,	– [1]
John W. Stubbs,	Boston,	Boric acid,	May 24, 1905,	Conviction.
George W. Wheeler,	Boston,	Boric acid,	Apr. 25, 1905,	Conviction.
Dustin D. Wright,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
George M. Long,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.

[1] Dismissed for want of prosecution.

For Sale of Adulterated Foods Other than Milk and Milk Products — Continued.

CLAMS.

NAME.	Place.	Adulterant.	Date.	Result.
Wm. M. Armstrong,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
Wm. C. Atwood,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
Alfred S. Higgins,	Boston,	Boric acid,	May 24, 1905,	Acquittal.[1]
R. R. Higgins Company,	Boston,	Boric acid,	June 14, 1905,	Conviction.
Dustin D. Wright,	Boston,	Boric acid,	Apr. 18, 1905,	Conviction.
John Mulligan,	Cambridge,	Boric acid,	June 6, 1905,	Conviction.
John H. Cone,	Worcester,	Boric acid,	Aug. 9, 1905,	Conviction.

EGGS.

Morris Brown,	Boston,	Formaldehyde,	July 24, 1905,	Conviction.
Morris Brown,	Boston,	Formaldehyde,	July 24, 1905,	Conviction.
Morris Brown,	Boston,	Formaldehyde,	July 24, 1905,	Conviction.

TOMATO CATSUP.

Edric Eldridge,	Boston,	Benzoic acid and coloring.	Apr. 18, 1905,	Conviction.
James J. Loughery,	Boston,	Benzoic acid,	Apr. 26, 1905,	Conviction.
Harry Redden,	Boston,	Benzoic acid,	July 27, 1905,	Conviction.
Calvin B. Smith,	Boston,	Benzoic acid,	Apr. 18, 1905,	Conviction.
Cleon G. Towne,	Boston,	Benzoic acid and coloring.	May 24, 1905,	Conviction.

VINEGAR.

Mathias Morris,	Provincetown,	- -	Sept., 1905,	Pending.

LIME JUICE.

Charles Connors,	Boston,	43 per cent. added water.	July 27, 1905,	Conviction.
C. Frank Hurley,	Boston,	63 per cent. added water.	Sept. 13, 1905,	Conviction.
Edward C. Ward,	Boston,	Sulphurous acid, 63 per cent. added water.	July 27, 1905,	Conviction.
Edward C. Ward,	Boston,	Salicylic acid, 62 per cent. added water.	July 27, 1905,	Conviction.
James H. Folkins,	Chelsea,	Sulphurous acid, salicylic acid, 56 per cent. added water.	Sept. 13, 1905,	Conviction.
Edward C. Ward,	Woburn,	Sulphurous acid, 50 per cent. added water.	Aug. 31, 1905,	Conviction.

[1] Warrant defective.

For Sale of Adulterated Foods Other than Milk and Milk Products — Continued.

SPICES.

Ginger.

NAME.	Place.	Adulterant.	Date.	Result.
Andrew J. Lovell, . .	Boston, . .	Turmeric, . .	Apr. 25, 1905,	Conviction.

Mace.

NAME.	Place.	Adulterant.	Date.	Result.
Henry A. Johnson, . .	Boston, . .	Wild mace and nutmeg.	Mar. 6, 1905,	Conviction.
Thomas V. L. Johnson, .	Boston, . .	Wild mace, . .	Mar. 6, 1905,	Conviction.
Joseph W. Bushman, .	Fall River, . .	False mace, . .	Mar. 15, 1905,	Conviction.

Mustard.

NAME.	Place.	Adulterant.	Date.	Result.
Harry Redden, . . .	Boston, . .	Wheat and turmeric,	July 27, 1905,	Conviction.

Pepper.

NAME.	Place.	Adulterant.	Date.	Result.
Harry Redden, . . .	Boston, . .	Ground fruit stones and nutshells.	July 27, 1905,	Conviction.

EXTRACT OF LEMON.

NAME.	Place.	Adulterant.	Date.	Result.
Albert J. Gibson,[1] . .	North Adams, .	Wood alcohol, 40 per cent.	Sept. 15, 1905,	Conviction.
William J. Bracey,[1] . .	South Boston, .	Wood alcohol, 40 per cent.	June 29, 1905,	Conviction.
William J. Bracey,[1] . .	South Boston, .	Wood alcohol, 40 per cent.	June 30, 1905,	Conviction.
William J. Bracey,[1] . .	South Boston, .	Wood alcohol, 40 per cent.	June 30, 1905,	Conviction.
William H. Newell,[1] . .	Springfield, .	Wood alcohol, 40 per cent.	June 27, 1905,	Acquittal.

EXTRACT OF VANILLA.

NAME.	Place.	Adulterant.	Date.	Result.
Thomas R. Linton, . .	Boston, . .	Admixture of coumarin.	Aug. 10, 1905,	Conviction.

JAM.

NAME.	Place.	Adulterant.	Date.	Result.
Charles E. Barton, . .	Cambridge, . .	Benzoic acid, . .	Mar. 18, 1905,	Conviction.
Charles C. Davis, . .	Cambridge, . .	Benzoic acid, . .	Sept. 29, 1905,	Conviction.
Edward E. Davis, . .	Cambridge, . .	Benzoic acid, . .	Sept. 29, 1905,	Conviction.

MAPLE SUGAR.

NAME.	Place.	Adulterant.	Date.	Result.
Walker-Rintels Company,	Boston, . .	Refined cane sugar,	May 24, 1905,	Conviction.
Albert Lockettl, . . .	Brockton, . .	Refined cane sugar,	Feb. 21, 1905,	Conviction.
Charles Carbone, . .	Haverhill, . .	Refined cane sugar,	Apr. 17, 1905,	Conviction.
D. Garborino, . . .	So. Framingham,	Refined cane sugar,	Mar. 24, 1905,	Conviction.

[1] Brought under chapter 220, Acts of 1905, relating to wood alcohol.

For Sale of Adulterated Foods Other than Milk and Milk Products — Continued.

MAPLE SYRUP.

NAME.	Place.	Adulterant.	Date.	Result.
Frank Whitcher,	Ayer,	Cane sugar syrup,	Apr. 13, 1905,	Conviction.
Frank Whitcher,	Ayer,	Cane sugar syrup,	June 3, 1905,	Acquittal.
Michael R. Barry,	Boston,	Cane sugar syrup,	June 30, 1905,	Conviction.
Max Braman,	Boston,	Cane sugar syrup,	July 25, 1905,	Conviction.
David Freshman,	Boston,	Cane sugar syrup,	Feb. 23, 1905,	Conviction.
David Freshman,	Boston,	Cane sugar syrup,	Feb. 23, 1905,	Conviction.
Charles H. Porter,	Boston,	Cane sugar syrup,	Mar. 6, 1905,	Conviction.
Claudius M. Tice,	Boston,	Cane sugar syrup,	July 27, 1905,	Conviction.
Vincen H. Fairey,	Brockton,	Cane sugar syrup,	Feb. 14, 1905,	Conviction.
Joseph A. Adams,	Fall River,	Cane sugar syrup,	Mar. 15, 1905,	Conviction.
Charles E. Peloquin,	Fall River,	Cane sugar syrup,	Mar. 15, 1905,	*Nol. pros'd.*
Leander L. Knowles,	Haverhill,	Cane sugar syrup,	Apr. 17, 1905,	Conviction.
Charles L. Walker,	Haverhill,	Cane sugar syrup,	Apr. 17, 1905,	Conviction.
Benj. F. Chamberlin,	Walpole,	Cane sugar syrup,	Mar. 6, 1905,	Conviction.

COCOA.

Herbert W. Locke,	Lowell,	Large admixture of sugar and wheat starch.	Mar. 10, 1905,	Conviction.

CREAM OF TARTAR.

John H. Cochran,	Boston,	Cornstarch, calcium sulphate, calcium acid phosphate.	May 4, 1905,	-[1]
Arthur B. Ryan,	Boston,	Cornstarch, calcium sulphate, calcium acid phosphate.	May 4, 1905,	Conviction.
Arthur B. Ryan,	Boston,	Cornstarch, calcium sulphate, calcium acid phosphate.	Feb. 28, 1905,	Conviction.
Peter J. Smith,	Cambridge,	Cornstarch, calcium sulphate, calcium acid phosphate.	Mar. 4, 1905,	Conviction.
Morris B. Silverman,	Fitchburg,	Cornstarch, calcium sulphate, calcium acid phosphate.	Mar. 1, 1905,	Conviction.
Isaac Kulwinsky,	Milford,	Cornstarch, calcium sulphate, calcium acid phosphate.	Apr. 11, 1905,	Conviction.
William P. Moshier,	Milford,	Cornstarch, calcium sulphate, calcium acid phosphate.	Apr. 20, 1905,	Conviction.

BAKING POWDER BEARING NO FORMULA.

Harry Redden,	Boston,	- -	July 27, 1905,	Conviction.

[1] Dismissed for want of prosecution.

For Sale of Adulterated Foods Other than Milk and Milk Products — Continued.

"CREAM SODA."

NAME.	Place.	Adulterant.	Date.	Result.
Duncan Matherson, . .	Provincetown, .	Salicylic acid, . .	Sept. 13, 1905,	Conviction.

GINGER ALE.

Charles F. Bray, Jr., . .	Gloucester, . .	Salicylic acid, . .	Sept. 23, 1905,	Acquittal.
Arthur C. Wheaton, . .	New Bedford, .	Salicylic acid, . .	Sept. 8, 1905,	Conviction.
Daniel E. Tilton, . .	Newburyport, .	Salicylic acid, . .	Sept. 13, 1905,	Conviction.
Martin W. Grimmin, . .	Spencer, . .	Salicylic acid, . .	June 26, 1905,	Acquittal.

STRAWBERRY TONIC.

Duncan Matherson, . .	Provincetown, .	Salicylic acid, . .	Sept. 13, 1905,	Conviction.

CIDER (DUFFY'S).

Henry J. Zoller, . . .	Boston, . .	Benzoic acid, . .	Apr. 13, 1905,	Conviction.
Henry J. Zoller, . . .	Boston, . .	Benzoic acid, . .	Apr. 13, 1905,	Conviction.
Henry J. Zoller, . . .	Boston, . .	Benzoic acid, . .	Apr. 13, 1905,	Conviction.

BEER.

William Albrecht, . .	Boston, . .	Fluoride, . . .	Sept. 13, 1905,	Conviction.
John Drewson, . . .	Boston, . .	Fluoride, . . .	Sept. term,[1] .	Pending.
Harvard Brewing Co., .	Boston, . .	Salicylic acid, . .	Apr. 8, 1905,	Conviction.
Harvard Brewing Co., .	Boston, . .	Fluoride, . . .	Sept. term,[1] .	Pending.
New England Brewing Co.,	Boston, . .	Salicylic acid, . .	May 9, 1905,	Conviction.
New England Brewing Co.,	Boston, . .	Salicylic acid, . .	May 9, 1905,	Conviction.
Waldberg Brewing Co., .	Boston, . .	Fluoride, . . .	Sept. 13, 1905,	Conviction.
Michael T. Dwyer, . .	Clinton, . .	Salicylic acid, . .	July 20, 1905,	Conviction.
Timothy McNamara, . .	Spencer, . .	Salicylic acid, . .	June 19, 1905,	Conviction.
Moses Morin, . . .	Spencer, . .	Salicylic acid, . .	June 19, 1905,	Conviction.
Bowler Bros., . . .	Worcester, . .	Salicylic acid, . .	May 16, 1905,	Acquittal.
Bowler Bros., . . .	Worcester, . .	Salicylic acid, . .	May 16, 1905,	Acquittal.
Bowler Bros., . . .	Worcester, . .	Salicylic acid, . .	May 16, 1905,	Acquittal.

[1] Indictment by grand jury.

For Sale of Adulterated Foods Other than Milk and Milk Products — Continued.

PORTER.

NAME.	Place.	Adulterant.	Date.	Result.
A. G. Van Nostrand, . .	Boston, . .	Salicylic acid, . .	Sept. term,[1] .	Pending.
Thomas F. Burke, . .	Clinton, . .	Salicylic acid, . .	July 20, 1905,	Conviction.
Thomas H. Hastings, .	Clinton, . .	Salicylic acid, . .	July 20, 1905,	Conviction.
Patrick H. Morrison, . .	Clinton, . .	Salicylic acid, . .	July 20, 1905,	Conviction.
Daniel F. Conlon, . .	Lawrence, . .	Salicylic acid, . .	Aug. 30, 1905,	Conviction.
James P. Hollihan, . .	Lawrence, . .	Salicylic acid, . .	Aug. 30, 1905,	–[1]
William H. Hennessy, .	Lynn, . . .	Salicylic acid, . .	Sept. 26, 1905,	Conviction.
Thomas E. Ryan, . .	Lynn, . . .	Salicylic acid, . .	Sept. 26, 1905,	Conviction.
Michael A. Lilla, . .	Webster, . .	Salicylic acid, . .	Aug. 29, 1905,	Conviction.
Bernard F. Miller, . .	Webster, . .	Salicylic acid, . .	Aug. 29, 1905,	Conviction.
Bowler Bros., . . .	Worcester, . .	Salicylic acid, . .	May 16, 1905,	Acquittal.
Bowler Bros., . . .	Worcester, . .	Salicylic acid, . .	May 16, 1905,	Acquittal.
John Brophy, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Samuel F. Daly, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Frank J. Deignan, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Sarah G. Donaher, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Acquittal.
Thomas J. Donaher, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
John F. Doyle, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Acquittal.
Peter Doyle, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Patrick McLaughlin, .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Michael F. O'Day, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
John J. O'Shea, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Patrick O'Shea, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.

ALE.

NAME.	Place.	Adulterant.	Date.	Result.
Frank H. Adams, . .	Boston, . .	Fluoride, . . .	Sept. term,[2] .	Pending.
William Albrecht, . .	Boston, . .	Fluoride, . . .	Sept. 13, 1905,	Conviction.
William Albrecht, . .	Boston, . .	Fluoride, . . .	Sept. 13, 1905,	Conviction.
Harvard Brewing Co., .	Boston, . .	Fluoride, . . .	Sept. term,[2] .	Pending.
Frank Jones Brewing Co.,	Boston, . .	Salicylic acid, . .	May 9, 1905,	Conviction.
Frank Jones Brewing Co.,	Boston, . .	Salicylic acid, . .	May 9, 1905,	Conviction.
Frank Jones Brewing Co.,	Boston, . .	Salicylic acid, . .	May 9, 1905,	Conviction.
Frank Jones Brewing Co.,	Boston, . .	Salicylic acid, . .	May 9, 1905,	Conviction.
Frank Jones Brewing Co.,	Boston, . .	Salicylic acid, . .	May 9, 1905,	Conviction.

[1] Dismissed for want of prosecution. [2] Indictment by grand jury.

For Sale of Adulterated Foods Other than Milk and Milk Products — Continued.

ALE — *Continued.*

Name.	Place.	Adulterant.	Date.	Result.
Frank Jones Brewing Co.,	Boston,	Salicylic acid,	May 9, 1905,	Conviction.
Frank Jones Brewing Co.,	Boston,	Salicylic acid,	May 9, 1905,	Conviction.
Mass. Breweries Co.,	Boston,	Sulphurous acid,	Mar. 11, 1905,	Conviction.
Mass. Breweries Co.,	Boston,	Sulphurous acid,	Mar. 11, 1905,	Conviction.
Mass. Breweries Co.,	Boston,	Fluoride,	Sept. term,[1]	Pending.
Mass. Breweries Co.,	Boston,	Fluoride,	Sept. term,[1]	Pending.
Mass. Breweries Co.,	Boston,	Fluoride,	Sept. term,[1]	Pending.
Mass. Breweries Co.,	Boston,	Fluoride,	Sept. term,[1]	Pending.
Mass. Breweries Co.,	Boston,	Fluoride,	Sept. term,[1]	Pending.
Mass. Breweries Co.,	Boston,	Fluoride,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
A. G. Van Nostrand,	Boston,	Salicylic acid,	Sept. term,[1]	Pending.
Thomas F. Burke,	Clinton,	Salicylic acid,	July 20, 1905,	Conviction.
Michael T. Dwyer,	Clinton,	Salicylic acid,	July 20, 1905,	Conviction.
Thomas H. Hastings,	Clinton,	Salicylic acid,	July 20, 1905,	Conviction.
Patrick H. Morrison,	Clinton,	Salicylic acid,	July 20, 1905,	Conviction.
Daniel F. Conlon,	Lawrence,	Salicylic acid,	Aug. 30, 1905,	Conviction.
Ernest L. Davis,	Lynn,	Salicylic acid,	Sept. 26, 1905,	Conviction.
George E. Hill,	Lynn,	Salicylic acid,	Sept. 26, 1905,	Conviction.
William E. Johnson,	Lynn,	Salicylic acid,	Sept. 26, 1905,	Conviction.
Wallace H. Martin,	Lynn,	Salicylic acid,	Sept. 26, 1905,	Conviction.
Sylvester P. Miles,	Lynn,	Salicylic acid,	Sept. 26, 1905,	Conviction.
Laurin M. Rollins,	Lynn,	Salicylic acid,	Sept. 26, 1905,	Conviction.
Frank Wherty,	Lynn,	Salicylic acid,	Sept. 26, 1905,	Conviction.
Edward Fitzgerald,	North Adams,	Salicylic acid,	July 28, 1905,	Conviction.
Owen W. Welsh,	North Adams,	Salicylic acid,	July 28, 1905,	Conviction.
Charles F. Grok,	Webster,	Salicylic acid,	Aug. 29, 1905,	Conviction.
Michael A. Lilla,	Webster,	Salicylic acid,	Aug. 29, 1905,	Conviction.
Bernard F. Miller,	Webster,	Salicylic acid,	Aug. 29, 1905,	Conviction.

[1] Indictment by grand jury.

For Sale of Adulterated Foods Other than Milk and Milk Products — Concluded.

ALE — *Concluded.*

Name.	Place.	Adulterant.	Date.	Result.
Bowler Bros., ...	Worcester, . .	Salicylic acid, . .	May 16, 1905,	Acquittal.
Elizabeth A. Bradley, .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Acquittal.
James F. Bradley, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Acquittal.
John Brophy, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Samuel F. Daly, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Frank J. Deignan, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Sarah G. Donaher, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Acquittal.
Thomas J. Donaher, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
John F. Doyle, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Acquittal.
Peter Doyle, ...	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
George F. Hewett Company,	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Gustaf Johnson, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Patrick McLaughlin, .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Michael F. O'Day, . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
John J. O'Shea, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
Patrick O'Shea, . . .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.
E. S. Pierce Company, .	Worcester, . .	Salicylic acid, . .	Aug. 9, 1905,	Conviction.

PORT WINE.

Lawrence A. Shortell, .	Boston, . .	Glucose, salicylic acid and coloring.	July 25, 1905,	Conviction.

For Sale of Adulterated Drugs.

BORAX.

F. E. Campbell, . . .	Springfield, .	Sodium bicarbonate; no borax.	June 27, 1905,	Conviction.

DISTILLED WATER.

Frank A. Epstein, . .	Boston, . .	4.2 parts solids per 100,000.	Feb. 28, 1905,	Conviction.
John M. Burke, . . .	Fall River, . .	4 parts solids per 100,000.	Mar. 8, 1905,	Conviction.

EXTRACT OF GINGER.

John J. Forrest, . .	Lawrence, . .	Solids, .85 per cent.; no oil; or resin.	Sept. 29, 1905,	Acquittal.

For Sale of Adulterated Drugs — Continued.

EXTRACT OF LIQUORICE.

NAME.	Place.	Adulterant.	Date.	Result.
Joshua L. Shikes,	Boston,	Wheat starch,	Apr. 18, 1905,	– [1]

OIL OF LEMON.

Henry L. Green,	Worcester,	A foreign oil,	Sept. 21, 1905,	Acquittal.

OLIVE OIL.

Arthur Tessier,	Boston,	Cotton seed oil,	Apr. 18, 1905,	Conviction.
Fred B. Morse,	Marlborough,	Cotton seed oil,	Feb. 24, 1905,	Conviction.

SPIRITS OF CAMPHOR.

Harry W. Parker,	Lowell,	Deficiency in strength.	Feb. 16, 1905,	Conviction.

TINCTURE OF IODINE.

Frank A. Epstein,	Boston,	Low in iodine,	Feb. 28, 1905,	Conviction.
Ralph B. Quinlan,	Boston,	Low in iodine,	Mar. 17, 1905,	Conviction.
Arthur Tessier,	Boston,	Low in iodine,	Apr. 18, 1905,	Conviction.
Edward H. Conley,	Brockton,	Low in iodine,	Feb. 18, 1905,	Conviction.
Joseph T. Lang,	Brockton,	Low in iodine,	Feb. 21, 1905,	Conviction.
John M. Burke,	Fall River,	Low in iodine,	Mar. 8, 1905,	Conviction.
John H. Mitchell,	Haverhill,	Low in iodine,	Apr. 17, 1905,	Conviction.
William F. Phelps,	Lynn,	Low in iodine,	September,	Pending.
David W. Faulkner,	Malden,	Low in iodine,	June 23, 1905,	Conviction.
William P. Sheldon,	Malden,	Low in iodine,	June 23, 1905,	Conviction.
William P. Sheldon,	Malden,	Low in iodine,	Sept. 21, 1905,	Conviction.
Fred B. Morse,	Marlborough,	Low in iodine,	Feb. 24, 1905,	Conviction.
John F. Payne,	Newtonville,	Low in iodine,	Mar. 28, 1905,	Conviction.
Daniel P. Grosvenor,	Peabody,	Low in iodine,	Feb. 25, 1905,	Conviction.
Bernard H. B. Adams,	Salem,	Low in iodine,	June 14, 1905,	Conviction.
W. M. Kennedy,	Ware,	Low in iodine,	July 19, 1905,	Conviction.

ZINC OINTMENT.

Ralph B. Quinlan,	Boston,	Low in zinc oxide,	Mar. 17, 1905,	Conviction.
Andrew L. Rickey,	Haverhill,	Low in zinc oxide,	Apr. 17, 1905,	Conviction.

[1] Dismissed for want of prosecution.

The amount paid in fines was $8,486, as follows: —

Milk and milk products,	$1,308
Foods other than above,	6,390
Drugs,	788
	$8,486

The expenditures for the year were as follows: —

Salaries of analysts,	$5,014 99
Salaries of inspectors,	4,059 99
Travelling expenses and purchase of samples,	1,992 83
Apparatus and chemicals,	814 31
Printing,	28 78
Services, cleaning laboratory,	86 00
Express and telegrams,	13 38
Sundry laboratory supplies,	132 55
Typewriting supplies and stationery,	10 10
Books,	51 93
Extra services,	181 00
Total,	$12,385 86

REPORT OF THE ANALYST.

By Albert E. Leach.

REPORT OF THE ANALYST.

By Albert E. Leach.

Dr. Charles Harrington, *Secretary*, *State Board of Health*.

Dear Sir: — I herewith submit my report on the analysis of food and drugs for the year ending Sept. 30, 1905.

The proportion of foods found to be adulterated during the year is considerably higher than for many years preceding, but there are several reasons for this difference. One is that more attention than usual has been paid to special classes of foods, some of which never have been examined in such large numbers before, and in which particular forms of adulteration, in some cases new, have been found. Incidentally it would follow that a smaller number of the routine articles, which have been examined for so many years, have been collected.

It is a fact that more interest than ever before has been shown of late on the part of the public at large in the subject of pure food, due, no doubt, to the increased number of States that are enforcing food laws, and to attempts made to secure national pure food legislation. Exaggerated statements showing the high ratio of adulteration of food on sale in Massachusetts have recently appeared in popular magazines, quotations being made apparently in good faith from the annual reports of the Board, giving the erroneous impression that the ratio of adulteration of the various brands of foods examined is a fair criterion of the quality of these foods as they are found in the market. For this reason it seems desirable to call attention again to the fact that as a rule only such foods as are likely to be adulterated are collected for examination. Furthermore, it should be understood that, with the exception of milk, actual adulteration of food is confined to a very small portion of the supply, since staple articles, such as cereals, fruits, vegetables, eggs in the shell, and fresh meats in joints and cuts, are from their nature rarely subject to adulteration. It is the less-used classes of prepared foods, canned goods, condiments, beverages and spices that are most liable to adulteration. Even in the classes of foods in which adulteration is most common, the suspicious samples or brands which are found to be adulterated form but a small proportion.

In the analyst's report for 1903 such standards of purity for food products as then had been adopted by the United States Department of Agriculture were included. Since that time schedules have been further adopted for grains, including the common flours and meals, for gluten flour, candy, honey, wines and vinegar.

Milk.

As in the case of other foods, the ratio of adulteration of milks examined is higher than usual. Of 3,164 samples analyzed, 1,323, or 41.8 per cent., were found to be adulterated, or below the statute standard. Here, as in the case of other foods, special attention has been paid to milk from suspicious sources. Again, on account of the proved value of the method for the detection of added water in milk by means of the refractometer, as outlined in the analyst's report for 1903, more samples of milk than usual have this year been classed as actually adulterated. Hence the ratio of adulteration of the milk examined by us is by no means indicative of the purity of the milk supply of the State.

The usual statistics follow, showing the geographical distribution throughout the State of the milk samples examined in the laboratory during the year, as well as the quality of the milk by months.

Milk from Cities.

Cities.	Number above Standard.	Number below Standard.	Total Samples collected.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with —		Number of Samples preserved with Formaldehyde.
						Annatto.	Aniline Orange.	
Beverly,	6	8	14	8.20	–	–	1	–
Boston,	215	228	443	10.64	–	–	–	–
Brockton,	16	9	25	9.80	–	–	–	–
Cambridge,	84	74	158	11.60	–	–	–	–
Chelsea,	33	88	121	10.44	–	–	–	–
Everett,	20	25	45	11.24	–	–	–	–
Fall River,	75	30	105	10.06	–	–	–	1
Fitchburg,	40	16	56	10.48	1	–	–	–
Gloucester,	77	35	112	10.29	–	3	–	–
Haverhill,	35	40	75	9.48	1	–	–	–
Holyoke,	33	4	37	9.32	1	–	–	–
Lawrence,	9	21	30	9.41	–	–	–	–
Lowell,	60	87	147	9.80	–	–	3	–
Lynn,	22	8	30	11.94	–	–	–	–
Malden,	44	21	65	10.68	–	–	–	–
Marlborough,	15	14	29	10.32	1	–	–	–
Medford,	11	4	15	12.60	–	–	–	–
Melrose,	9	6	15	11.46	–	–	–	–
New Bedford,	23	23	46	11.29	–	–	–	–
Newburyport,	47	12	59	11.72	–	–	–	–
Newton,	37	26	63	11.64	–	–	–	–
North Adams,	19	1	20	11.25	–	–	–	–
Quincy,	20	15	35	11.80	–	–	–	–
Salem,	65	29	94	9.40	–	–	–	–
Somerville,	44	68	112	11.40	1	–	–	–
Springfield,	29	10	39	11.79	–	–	–	–
Taunton,	35	4	39	10.48	–	–	–	–
Waltham,	41	41	82	10.40	–	–	–	–
Woburn,	27	16	33	8.36	–	–	–	–
Worcester,	101	65	166	10.25	1	–	–	–
Summary,	1,282	1,028	2,310	8.20	6	3	4	1

Milk from Towns.

Towns.	Number above Standard.	Number below Standard.	Total Samples collected.	Total Solids in Lowest Sample.	Number of Skimmed Samples.
Attleborough,	109	23	132	9.50	1
Ayer,	9	3	12	12.47	–
Brookline,	65	27	92	11.60	–
Clinton,	13	5	18	12.55	–
Hyde Park,	26	27	53	10.44	–
Ipswich,	8	7	15	10.33	–
Lincoln,	11	9	20	11.31	–
Mansfield,	8	2	10	11.42	–
Milford,	34	5	39	10.80	1
Nantucket,	27	1	28	11.65	–
Natick,	30	6	36	10.20	4
Plymouth,	27	6	33	11.65	–
Provincetown,	15	3	18	9.49	–
Reading,	13	1	14	10.15	1
Revere,	22	24	46	10.20	–
Stoughton,	11	–	11	12.00	–
Ware,	13	3	16	11.12	–
Watertown,	7	19	26	12.10	–
Westborough,	11	–	11	12.00	–
Winthrop,	16	13	29	11.70	–
Summary,	475	184	659	9.49	7

Milk from Suspected Producers.

Locality.	Number above Standard.	Number below Standard.	Total Samples collected.	Total Solids in Lowest Sample.
Acton,	4	1	5	11.90
Colrain,	7	8	15	4.69
Dover,	1	10	11	10.38
Grafton,	2	7	9	9.34
Holliston,	–	6	6	10.56
Lexington,	4	4	8	12.09
Millis,	–	11	11	9.78
Sherborn,	15	3	18	12.07
Southborough,	–	10	10	11.33
Sudbury,	10	9	19	11.45
Warren,	–	6	6	10.00
Wayland,	–	8	8	9.95
West Brimfield,	5	6	11	9.03
Summary,	48	89	137	4.69

Summary of Milk Statistics.

	Number above Standard.	Number below Standard.	Total Samples collected.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with —		Number of Samples preserved with Formaldehyde.
						Annatto.	Aniline Orange.	
Milk from cities,	1,282	1,028	2,310	8.20	6	3	4	1
Milk from towns,	475	184	659	9.49	7	–	–	–
Milk from suspected producers,	48	89	137	4.69	–	–	–	–
Miscellaneous,	36	22	58	10.80	–	–	–	–
Summary,	1,841	1,323	3,164	4.69	13	3	4	1

Quality of Milk by Months.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Totals.
Number having more than 15 per cent. of total solids.	34	18	11	4	12	13	2	5	8	7	6	5	125
Number having between 14 and 15 per cent. of total solids.	36	38	44	30	16	18	6	9	11	10	12	7	237
Number having between 13 and 14 per cent. of total solids.	193	236	260	54	60	67	32	33	40	23	46	34	1,078
Number having between 12 and 13 per cent. of total solids.	287	266	204	44	59	130	93	61	63	59	60	57	1,383
Number having between 11 and 12 per cent. of total solids.	23	38	31	15	6	22	8	21	15	12	15	17	223
Number having between 10 and 11 per cent. of total solids.	15	9	14	4	1	5	3	17	5	5	1	1	80
Number having between 9 and 10 per cent. of total solids.	3	1	3	–	–	1	2	5	1	3	1	6	26
Number having between 8 and 9 per cent. of total solids.	–	2	1	–	–	–	3	–	–	2	–	–	8
Number having less than 8 per cent. of total solids.	–	–	–	–	–	–	4	–	–	–	–	–	4
Above standard, ...	263	293	316	90	89	98	133	109	122	101	124	103	1,841
Below standard, ...	328	315	252	61	65	158	20	42	21	20	17	24	1,323
Total, ...	591	608	568	151	154	256	153	151	143	121	141	127	3,164

Samples of artificially colored milk were collected in Gloucester, Lowell and Beverly. Three were colored with annatto and 4 with aniline orange. But 1 sample was found to be preserved with formaldehyde; this was obtained in Fall River. The effect of strict prosecution of samples of artificially colored and preserved milk is apparent from the reduced number of samples found to be thus adulterated.

The extent of the use of preservatives in milk during the past eight years in Massachusetts is shown in the following table: —

Preservatives in Milk.

YEAR.	Samples examined.	SAMPLES CONTAINING FORMALDEHYDE.		SAMPLES CONTAINING BORIC ACID.		Number containing Carbonate.	Total containing Preservative.
		Number.	Per Cent.	Number.	Per Cent.		
1898, . .	1,046	26	2.5	11	1.0	4	41
1899, . .	2,105	55	2.6	13	0.6	3	71
1900, . .	2,018	61	3.0	6	0.3	–	67
1901, . .	2,154	42	1.9	12	0.5	–	54
1902, . .	1,934	29	1.5	14	0.7	–	43
1903, . .	1,935	28	1.5	11	0.4	1	40
1904, . .	1,863	20	1.1	–	–	–	20
1905, . .	532	1	0.2	–	–	–	1
Summary,	13,587	262	1.93	67	0.49	8	337

Added Water in Milk, and its Detection.

Much additional work has been done during the year on the refractometric examination of milk serum as an index to watering. There has

been no occasion to change in any way the method as originally worked out and published in the analyst's report for 1903. It was thought best, however, before fixing a hard-and-fast limit of refraction under which all samples should be termed watered, to get together a large number of analyses of milk from a wide variety of sources. This has been done so far as opportunity has permitted, and occasional samples of milk collected by the inspectors in the routine of their work, as well as samples of known purity from herds, have been submitted to refractometric examination.

As associate referee on dairy products of the Association of Official Agricultural Chemists, the writer has collected as many authentic analyses, based on the use of the refractometer, as possible outside of Massachusetts, with a view to presenting the method in concrete form for provisional adoption by that association. A large number of tabulated results have been submitted by the Laboratory of Hygiene of the State of New Jersey and by a well-known firm of commercial chemists in Liverpool, Eng.

It can be stated positively that added water in milk can in most cases be detected by this method. Which is especially useful in cases where the total solids and solids not fat are not in themselves low enough to indicate the fact that water has been added. Indeed, in one instance added water was indicated positively in a sample of milk standing as high as 12.80 per cent. in total solids and 6.3 per cent. fat, the immersion refractometer reading at 20° C. being 36.3. This had been watered down from a sample of particularly rich milk, originally standing apparently between 17 and 18 per cent. in total solids. Milk of known purity from 2 small herds gave results of analyses as follows: —

Milk of Known Purity.

Breed.	Age of Cow (Years.)	Time since Calving (Months).	Determinations on Milk.								Determinations on Milk Serum.	
			Specific Gravity at 15°.	Water (Per Cent.).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not fat (Per Cent.).	Ash (Per Cent.).	Milk Sugar (Per Cent.).	Proteids (Per Cent.).	Specific Gravity at 15°.	Refraction at 20°.
Grade cows, other than Holstein.	8	½	1.0279	84.86	15.14	6.60	8.54	.67	5.08	2.79	1.0314	43.2
	5	12	1.0290	84.90	15.10	6.00	9.10	.67	4.83	3.60	1.0316	43.8
	7	1	1.0318	86.57	13.43	4.35	9.08	.72	4.83	3.53	–	43.6
	6	2	1.0309	87.04	12.96	4.15	8.81	.67	5.23	2.91	1.0319	44.0
	8	1	1.0287	87.30	12.70	4.10	8.60	.61	4.88	3.11	1.0303	42.3
	7	1	1.0288	88.92	11.08	3.10	7.98	.62	4.50	2.76	1.0285	40.9
	9	1	1.0299	89.20	10.80	2.70	8.10	.62	4.62	2.86	1.0289	41.1
Holstein, ...	6	2	1.0290	88.91	11.09	3.10	7.99	–	–	–	–	42.2
	9	2½	1.0271	88.97	11.03	3.60	7.43	–	–	–	–	40.7
	4	7	1.0265	89.12	10.88	3.45	7.43	–	–	–	–	39.8
	9	8	1.0276	89.24	10.76	3.10	7.66	–	–	–	–	40.7
Mixed milk of 12 Holstein cows.	–	–	1.0276	87.74	12.26	4.10	8.16	–	–	–	–	41.4
	–	–	1.0296	87.78	12.22	3.80	8.42	–	–	–	–	42.2

The following tables show a wide range of analyses made in the laboratory during the year: —

Refraction Readings of Milk above the Standard, 34 Samples.

Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Refraction of Serum at 20°.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Refraction of Serum at 20°.
14.54	5.10	9.44	43.0	13.02	3.90	9.12	42.2
14.50	5.15	9.35	42.9	13.00	4.10	8.90	42.2
14.46	4.40	10.06	45.0	12.99	3.80	9.19	42.9
14.44	5.00	9.44	43.1	12.98	4.00	8.98	42.7
14.35	4.00	10.35	42.2	12.88	3.80	9.08	42.5
14.25	4.60	9.65	43.7	12.84	3.95	8.89	42.8
13.82	4.15	9.67	44.0	12.73	3.80	8.93	42.5
13.66	4.30	9.36	43.8	12.70	3.60	9.10	42.5
13.55	4.60	8.95	43.0	12.64	3.55	9.09	42.7
13.40	3.85	9.55	43.5	12.58	3.80	8.78	41.4
13.35	4.00	9.35	42.9	12.52	3.80	8.72	41.8
13.28	4.40	8.88	43.6	12.44	3.40	9.04	43.1
13.27	4.20	9.07	42.3	12.11	3.70	8.41	41.3
13.20	3.90	9.30	42.5	12.08	3.65	8.43	41.0
13.20	4.00	9.20	42.8	12.03	3.10	8.93	41.7
13.10	4.15	8.95	43.3	12.00	3.40	8.60	41.3
13.02	3.60	9.42	42.3	12.00	4.10	7.90	40.0
Highest,				14.54	5.15	10.06	45.0
Lowest,				12.00	3.10	7.90	40.0
Average,				13.14	4.02	9.12	42.9

Refraction Readings of Milk below the Standard, Added Water not alleged, 31 Samples.

Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Refraction of Serum at 20°.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Refraction of Serum at 20°.
11.65	2.90	8.75	41.1	11.08	2.50	8.58	42.1
11.76	3.55	8.21	41.6	11.07	2.00	9.07	42.7
11.60	2.80	8.80	39.3	11.05	3.20	7.85	39.0
11.60	3.25	8.35	41.2	11.03	3.20	7.83	39.3
11.60	3.45	8.15	40.0	10.91	2.60	8.31	39.7
11.51	3.45	8.06	40.8	10.87	3.10	7.77	40.2
11.50	2.30	9.20	43.9	10.86	2.85	8.01	40.2
11.44	3.40	8.04	39.5	10.82	3.00	7.82	40.1
11.40	2.80	8.60	42.6	10.78	3.00	7.78	39.3
11.40	3.35	8.05	40.0	10.68	2.30	8.38	40.6
11.39	3.55	7.84	40.3	10.58	2.55	8.03	41.2
11.33	3.50	7.83	40.0	10.50	2.20	8.30	42.8
11.30	2.60	8.70	42.7	10.44	1.50	8.94	43.3
11.30	3.60	7.70	39.6	10.40	2.40	8.00	41.2
11.29	3.25	8.04	41.1	10.27	2.40	7.87	40.0
11.20	3.30	7.90	39.7				
Average,				11.04	2.85	8.19	40.7

From these figures it would seem that the minimum of 39 as a refractometric reading of the milk serum at 20° is a conservative one for pure milk. A sample showing a reading of less than this figure can safely be alleged to contain added water, especially when in addition thereto the solids not fat in the sample are as low as 7.30 per cent. Abnormalities

may occur by reason of diseased conditions or incomplete milking, so that in rare cases certain samples of milk as taken from the cow might show a refractometric reading a trifle below 39, but such unnatural occurrences do not interfere with the success of the method.

The following table shows the analyses of samples of milk which were found adulterated by added water, and were so reported from the reading of the milk serum on the immersion refractometer: —

Milk Fraudulently Adulterated.

Dealer.	Locality.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Refraction of Serum at 20°C.	Foreign Substances.
Keefe Brothers,	Lowell,	11.37	3.25	8.12	39.4	Colored with aniline orange.
Wallace J. Lathrop,	Ipswich,	11.35	3.65	7.70	34.7	
A. S. Furtado & Son,	Fall River,	11.31	3.55	7.77	37.9	
Asa Burnham,	Holliston,	11.31	4.00	7.31	38.8	
John Geary,	Gloucester,	11.08	3.40	7.68	38.6	
Marcus Leach,	Brockton,	11.05	3.75	7.30	36.9	
Fingere Brothers,	Salem,	10.80	3.20	7.60	37.3	
Harry Isham,	Warren,	10.76	3.40	7.36	36.9	
Charles F. Chopin,	Lowell,	10.74	3.10	7.64	38.6	
Richard Binall,	Dover,	10.65	3.20	7.45	38.1	
Leude Tousignant,	Lowell,	10.51	3.00	7.51	38.0	Colored with aniline orange.
John J. Buckley,	Worcester,	10.46	3.30	7.16	36.8	
Fred Clarke,	Lowell,	10.46	3.60	6.86	35.7	Colored with aniline orange.
Fred W. Crooker,	Lowell,	10.44	3.35	7.09	36.1	
John Bowman,	Chelsea,	10.44	3.60	6.84	35.9	
Edward S. Wright,	Fall River,	10.40	3.20	7.20	36.9	Preserved with formaldehyde.
E. Robinson,	Gloucester,	10.29	3.10	7.19	36.3	Colored with annatto.
Patrick H. Martin,	Beverly,	10.26	3.40	6.86	35.8	Colored with aniline orange.
F. W. Marshall,	Gloucester,	10.31	3.05	7.26	37.0	
Alden D. Wellington,	Wayland,	9.95	2.70	7.25	38.3	
O. H. Keith,	Attleborough,	9.90	4.30	5.60	31.8	
George Cooke,	Millis,	9.78	2.90	6.88	36.9	
Aime Chabot,	West Brimfield,	9.56	3.00	6.56	35.3	
Stefan Bik,	Salem,	9.40	2.80	6.60	34.9	
Ernest R. Houghton,	Grafton,	9.34	2.82	6.52	35.2	
Annie E. Stephens,	Gloucester,	8.98	2.60	6.38	34.7	Colored with annatto.
J. L. Babson,	Gloucester,	8.98	2.65	6.33	34.7	Colored with annatto.
Geo. W. Warner,	Colrain,	7.32	2.00	5.32	31.9	
James H. Galvin,	Colrain,	4.69	0.25	4.44	28.7	

Most of these cases were prosecuted in the courts, and in several instances, where the milk stood above 11 per cent. in total solids, the defendant pleaded guilty to a complaint for selling watered milk.

In the above table a number of samples are shown to have been further adulterated with coloring matter or with preservative, in addition to added water. Watering and coloring frequently go together, the latter being practised to cover up evidence of the former.

In the curdling of milk for carrying out the regular process of separating the milk serum for refractometric examination, the curd is usually left in a compact mass that may be used for the further examination of added coloring matter, thus rendering it unnecessary to test for color in a separate sample of milk.

Goat's Milk.

In view of the fact that some interest has been shown of late in the breeding of goats for milk, and that several small herds of milch goats have been kept for purpose of experiment in Massachusetts, samples of milk of known purity from 6 goats were analyzed in December, 1904. This milk was kindly furnished by Mr. H. M. Hartshorn of Malden. Goat's milk averages considerably higher in total solids and in fat than cow's milk, and, except in richness, is hardly to be distinguished therefrom in flavor. Of the animals whose milk was analyzed, No. 1 had two kids eight weeks old. Besides suckling these kids, she gave one pint of milk morning and night. Nos. 2 and 3 were both near the end of their period of lactation, and were milked but once a day, No. 2 giving two ounces, while No. 3 gave about half a pint. No. 4 gave one quart per day, and Nos. 5 and 6 one and one-half pints each. It is understood that under the best conditions some of the choice milch goats can give from 3 to 4 quarts per day.

Analyses of Goat's Milk.

	Water (Per Cent.).	Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Ash (Per Cent.).	Milk Sugar (Per Cent.).	Proteids (Per Cent.).	Refraction at 20°C.	Butyro Refractometer Reading of Fat at 36.5°C.
No. 1,	85.22	14.78	4.20	10.58	.76	5.30	4.52	45.8	41.5
No. 2,	76.82	23.18	10.50	11.68	.90	–	–	–	40.6
No. 3,	79.56	20.44	8.70	11.74	.92	5.15	5.77	47.6	41.2
No. 4, morning,	81.00	19.00	7.40	11.60	.89	–	–	–	–
evening,	79.97	20.03	8.00	12.03	.91	–	–	–	–
No. 5, morning,	80.00	20.00	8.10	11.90	.93	–	–	–	–
evening,	78.50	21.50	9.70	11.80	.88	–	–	–	–
No. 6, morning,	79.84	20.16	7.55	12.61	.95	–	–	–	–
evening,	79.94	20.06	8.25	11.81	.86	–	–	–	–

Cream.

Twenty-eight samples of cream were examined, of which 7, or 25 per cent., were adulterated. Five of these samples were preserved with boric acid, and 2 contained calcium sucrate. Sucrate of lime is added for the evident purpose of increasing the consistency of the cream, thus making it appear to be of heavier body than it really is. Calcium sucrate is rendered apparent, when present, by the high alkalinity of the ash of the sample. In obtaining the alkalinity, 25 grams of the sample are burnt to an ash, which is treated with an excess of tenth-normal acid, this being titrated back with tenth-normal sodium hydroxide, using phenolphthalein as an indicator. The alkalinity of the ash of 100 grams of pure cream has been found to vary between the limits of 6.4 and 13.6. The alkalinity of the ash of 100 grams of the 2 samples found to contain calcium sucrate were found to be in one case 22.4 and in the other 19.2. The alkalinity of the ash of 100 grams of a sample of cream treated by the writer with 5 c. c. of calcium sucrate per quart (this being the amount commonly used) was found to be 18.8.

Condensed Milk.

In past reports for the past seven or eight years, analyses in full have been published of nearly all the standard brands of condensed milk on sale in Massachusetts. During the present year 23 samples of condensed milk were analyzed, only 2 of which were classed as adulterated, by reason of having been made from skimmed milk. These were the Middlesex Brand, having 6.6 per cent. of fat and 1.74 per cent. of ash, corresponding to a fat in the original milk of 2.64 per cent.; and the Red Clover Brand, with 0.6 per cent. of fat and 1.72 per cent. of ash, equivalent to a fat in the original milk of 0.74 per cent.

Butter.

Of the 105 samples examined, 5 were adulterated: 1 of these was oleomargarine sold for butter, while the other 4 were renovated butter not properly labelled.

Cheese.

Seventeen samples were examined, all of which were free from adulteration.

Cocoa.

Seventeen samples were analyzed, 4 of which were found to be adulterated.

The following brands were published in the monthly bulletin as being adulterated: —

Analyses of Adulterated Brands of Cocoa.

Brand.	Manufacturer or Wholesaler.	Adulterants.
The Mohican Company, . . .	- -	Sugar and wheat starch.
Ralston's Purina Health Cocoa, . .	Ralston Purina Company, St. Louis, Mo.	Sugar and wheat starch.
Scheuer's Instantaneous Lunch Cocoa,	S. Scheuer & Co., Paterson, N. J., .	Sugar.

Coffee.

Forty-three samples were analyzed, 6 of which were found to be adulterated.

Confectionery.

Twenty-five samples were examined, 1 of which was declared adulterated by reason of the fact that decomposed orange oil was used as a flavor. The recently adopted standard of the United States Department of Agriculture for candy is as follows: —

Candy is a product made from a saccharine substance or substances with or without the addition of harmless coloring, flavoring or filling materials, and contains no terra alba, barytes, talc, chrome yellow, or other mineral substances or poisonous colors or flavors, or other ingredients injurious to health.

Cream of Tartar.

One hundred and sixteen samples were analyzed, 6 of which were adulterated. Two adulterated brands were The Reliable, "absolutely pure," made by the Colonial Tea Company of Fitchburg, and The Purity, "absolutely pure," made by the Purity Baking Powder Company of Boston. Both brands were found to contain large admixtures of corn starch, calcium sulphate and calcium acid phosphate. One sample was found to contain, besides the above adulterants, alum; another consisted of bicarbonate of soda.

Egg.

Twenty-seven samples of broken egg, of the variety sold in bulk to bakers, were analyzed with special reference to the presence of preservatives. Five of these, the product of a single concern, were found to contain formaldehyde. Hitherto, the use of formaldehyde has been confined largely to the preservation of milk and cream, but it has been found to be a very effective deodorizer in the case of partly decomposed egg yolk. When the egg has become actually putrid, the odor may be entirely re-

moved by the addition of formaldehyde. In most cases when the latter agent is present to a considerable extent it may be detected by simply heating some of the egg yolk with hydrochloric acid and ferric chloride, in exactly the same manner as in the case of milk. It is usually found better, however, to add a small amount of pure milk to the sample before making the test, and for a confirmatory test to distil a small portion of the sample, and test the distillate with milk in the usual manner.

Flavoring Extracts.

The following brands of extracts were published in the monthly bulletins during the year as being adulterated: —

Analyses of Adulterated Brands of Flavoring Extracts.

Extract.	Brand.	Manufacturer or Wholesaler.	Lemon Oil (Per Cent.).	Grain Alcohol (Per Cent.).	Wood Alcohol (Per Cent.).
Lemon, .	- -	Charles Stuart & Co., Hartford, Conn.	0.5	-	-
Lemon, .	Concentrated, . . .	Myrtle Extract Company, Boston, Mass.	0.0	-	-
Lemon, .	Elmo, ...	Elmo Extract Company, Somerville, Mass.	0.05	-	-
Lemon, .	Good Value, . . .	Binghampton, N. Y., . .	0.0	48.1	-
Lemon, .	Gilt Edge Standard, . .	Anderson & Edwards, N. Y., .	1.5	50.0	-
Lemon, .	Eagle Extract Company, .	Farnsworth Street, Boston, .	0.0	39.9	-
Lemon, .	Harris' Pure, . . .	Frank E. Harris Company, Binghampton, N. Y.	3.3	80.6	-
Lemon, .	King Arthur Pure, . .	Mills Tea and Butter Company, Hartford, Conn.	5.0	45.0	45.0
Lemon, .	Kidder's Concentrated, .	Kidder & Co., Boston, Mass., .	1.0	66.8	-
Lemon, .	Miner's, ...	B. F. Miner, Montague, Mass.,	2.4	-	-
Lemon, .	Regal, ...	Regal Extract Company, Boston, Mass.	0.25	-	-
Lemon, .	St. John's, ...	St. John Extract Company, N. Y.	0.0	33.8	-
Lemon, .	Trumbull & Co's., . .	Hartford, Conn., . . .	0.0	-	-
Lemon, .	Quinsigamond Mills, .	- -	0.0	-	-
			Orange Oil.		
Orange,	King Arthur, . . .	Mills Tea and Butter Company, Hartford, Conn.	1.5	83.2	1.0
			Vanilla.	Coumarin.	
Vanilla,	Gilt Edge Standard, . .	Anderson & Edwards, N. Y., .	Present,	Present, .	-
Vanilla,	Golden Cap Concentrated,	Tremont Extract Company, .	Present,	Present, .	-
Vanilla,	Imperial, ...	- -	None, .	Present, .	-
Vanilla,	———. Picture of a basket of fruit on label.	- -	None, .	Present, .	-
Ginger, .	Walker's, ...	Walker Chemical and Extract Company, Boston, Mass.	No ginger-oil or resin.		
Ginger, .	O. K., ...	C. L. Cotton Perfume and Extract Company, Earlville, N. Y.	No ginger-oil or resin.		

Wood alcohol has for the first time been found this year in flavoring extracts. Indeed, this is the first time it has been found in any food product in Massachusetts, although its occurrence in drugs and pharmaceutical preparations has been noted.

Jamaica Ginger.

The 2 samples examined were both found to be practically free from ginger oil, without any label setting forth that such was the case.

Lemon Extract.

Forty-five samples were analyzed, of which 28 were classed as adulterated. Most of these had insufficient lemon oil, but 5 contained wood alcohol.

Orange Extract.

Two samples were examined, 1 of which was found to contain wood alcohol.

Vanilla Extract.

Twenty-nine samples were analyzed, 7 of which were adulterated.

Honey.

Thirty-two samples were analyzed, 1 of which was found to be adulterated, containing 60 per cent. of commercial glucose and 18 per cent. of cane sugar, without the label called for by law setting forth the name and percentage of the ingredients.

Jams and Jellies.

Fifty-two samples of these products were collected, of which 21 were found to be adulterated, chiefly by reason of the presence of cheaper fruit than that set forth on the label, and because of the presence of preservatives not mentioned on the label as required by law.

Adulterated brands published during the year included the following: —

Published Results of Analyses of Brands of Jams and Jellies.

Sample.	Manufacturer or Wholesaler.	Results of Analysis.
Currant jelly,	Ayer Preserving Company, Ayer, Mass.,	Apple jelly, colored with a coal tar dye.
Raspberry jelly,	Ayer Preserving Company, Ayer, Mass.,	Apple jelly, colored with a coal tar dye.
Strawberry jam,	Curtice Brothers, Rochester, N. Y.,	Preserved with benzoic acid.
Peach fruit jam, Raspberry jam, Quince jam, Strawberry jam, Damson jam,	Geo. K. McMeechen & Sons Company, Wheeling, W. Va.	Preserved with benzoic acid.

Ketchup.

Twenty-one samples were examined, 12 of which were found to contain preservatives not properly marked on the label.

Brands found to be adulterated were the following: —

Analyses of Adulterated Brands of Tomato Ketchup.

Brand.	Manufacturer or Wholesaler.	Antiseptic.
Berkshire Tomato Catsup,	Standard Packing Company, Indianapolis, Ind.,	Benzoic acid.
Bordeaux Tomato Catsup,	Standard Packing Company, Indianapolis, Ind.,	Benzoic acid.
– –	Boston Butter and Tea House, Worcester, Mass.,	Benzoic acid.
Home Made Catsup,	Downing, Taylor Company, Springfield, Mass.,	Benzoic acid.
Leroy Tomato Catsup,	Leroy Packing Company, Boston, Mass.,	Benzoic acid.
Reliable,	Eldridge, Baker & Bain, Boston, Mass.,	Benzoic acid.
– –	T. A. Snider Conserve Company, Cincinnati, O.,	Benzoic acid.
Waldorf Tomato Catsup,	The Williams Bros. Company, Detroit, Mich.,	Benzoic acid.

Lard.

Twenty-four samples were examined, 3 of which were adulterated with cotton-seed oil: —

Lime Juice.

Seventeen samples of lime juice were examined, none of which was found to conform with the requirements of the law, though some of them contained misleading or erroneous formulas.

The following brands were published as adulterated: —

Published Results of Analyses of Lime Juice.

Brand.	Manufacturer or Wholesaler.	Citric Acid (Per Cent.).	Added Water (Per Cent.).	Antiseptic.
Banner,	Simpson Spring Company, So. Easton, Mass.,	2.71	61	Sulphurous acid.
Bee,	Geo. Wm. Bentley Company, Boston, Mass.,	3.40	51	Benzoic acid.
Crown,	J. P. W. Von Laer & Co., Boston, Mass.,	3.92	44	Salicylic acid.
Danish West India,	– –	2.48	65	Sulphurous acid.
Dominica,	Eagle Extract Company, Boston, Mass.,	2.62	63	Sulphurous acid.
Favorite,	J. T. Connor Company, Boston, Mass.,	3.91	44	Sulphurous acid and salicylic acid.
Manhattan Club,	J. H. Folkins Company, Boston, Mass.,	3.10	56	Sulphurous acid and salicylic acid.
Montego,	– –	2.67	62	Salicylic acid.
Princess,	J. P. W. Von Laer & Co., Boston, Mass.,	2.39	66	Salicylic acid.
Rose's,	L. Rose & Co., Limited, London, Eng.,	7.85	–	Sulphurous acid.
Von Laer's,	J. P. W. Von Laer & Co., Boston, Mass.,	4.35	35	Salicylic acid.
West India,	Eagle Extract Company, Boston, Mass.,	2.64	62	Sulphurous acid.
West India,	Jamaica Fruit Company, Boston, Mass.,	2.83	60	Sulphurous acid.
Walker's,	Walker Extract Company, Chelsea, Mass.	2.17	69	Sulphurous acid and salicylic acid.

Malt Liquors.

Particular attention has been paid this year to the question of preservatives in malt liquors, with the result that a large proportion of the brands sold on the market have been found to be thus adulterated. Three hundred and twelve samples of beer, ale and porter were analyzed, 118 of which contained preservatives.

The following are the brands published in the monthly bulletins as being adulterated: —

Published Analyses of Adulterated Brands of Malt Liquors.

Brand.	Manufacturer or Wholesaler.	Number of Samples containing — Salicylic Acid.	Sulphurous Acid.	Fluorides.
W. A. Extra Pale Ale,	Wm. Albrecht, Boston, Mass.,	–	–	2
Canada Malt Ale,	Ballantine & Co., Newark, N. J.,	–	–	2
Export Beer,	Ballantine & Co., Newark, N. J.,	–	–	1
Lager Beer,	Bartholomay Lager Beer, Rochester, N. Y.,	–	–	1
India Pale Ale,	The Bergner & Engel Breweries Company, Philadelphia, Pa.,	2	–	–
East India Pale Ale,	J. F. Betz & Son, Philadelphia, Pa.,	1	–	–
Tadcaster Ale,	Bowler Bros., Worcester, Mass.,	3	–	–
Sparkling Ale,	Bowler Bros., Worcester, Mass.,	2	–	–
Matchless Porter,	Bowler Bros., Worcester, Mass.,	1	–	–
Van Nostrand's P. B. Ale,	Bunker Hill Breweries, Boston, Mass.,	12	1	–
Van Nostrand's Old Stout,	Bunker Hill Breweries, Boston, Mass.,	1	–	–
Colonial Beer,	Burton Breweries, Boston, Mass.,	2	–	–
India Pale Ale,	C. H. Evans & Sons, Hudson, N. Y.,	1	–	–
Special Stock Ale,	Chr. Fiegenspan, Newark, N. J.,	1	–	–
Belladear Lager Beer,	Glenbrook Distilling Company, Boston, Mass.,	5	–	–
Harvard $1,000 Pure Beer,	Harvard Brewing Company, Lowell, Mass.,	2	–	1
Harvard Sparkling Ale,	Harvard Brewing Company, Lowell, Mass.,	–	–	1
Cream Stock Ale,	W. J. Higgins & Co., Boston, Mass.,	–	–	1
Homestead Ale,	Frank Jones Brewing Company, Portsmouth, N. H.,	1	–	–
India Pale Ale,	Frank Jones Brewing Company, Portsmouth, N. H.,	7	–	–
Extra Pale Ale,	Wm. J. Lemp, St. Louis, Mo.,	–	–	1
Imported Pilsner Beer,	August Lüchow, New York,	–	–	1
Cook's Cream Ale,	Massachusetts Breweries Company, Boston, Mass.,	–	–	1
Extra Pale Ale,	Massachusetts Breweries Company, Boston, Mass.,	–	–	1
Gem Sparkling Ale,	Massachusetts Breweries Company, Boston, Mass.,	–	–	1
Golden Ale,	Massachusetts Breweries Company, Boston, Mass.,	–	–	1
Red Fox Ale,	Massachusetts Breweries Company, Boston, Mass.,	–	2	–
Robinson's India Pale Ale,	Massachusetts Breweries Company, Boston, Mass.,	–	–	1
Robinson's Pale Ale,	Massachusetts Breweries Company, Boston, Mass.,	–	–	1
Salzburger Beer,	McCormick Brewing Company, Boston, Mass.,	1	–	–
Lager Beer,	Narragansett Brewing Company, Providence, R. I.,	–	–	1
Bull's Head Ale,	Souther Brewing Company, Boston, Mass.,	3	–	–
Burton Stock Ale,	Souther Brewing Company, Boston, Mass.,	1	–	–
Hampden Stock Ale,	Springfield Breweries Company, Springfield, Mass.,	1	–	–
Lager Beer,	Waldberg Breweries,	–	–	1
Ehret's New York Lager,	Jacob Wirth, Boston, Mass.,	–	–	1
Total,		47	3	20

Published Results of Analyses of Adulterated Malt Liquors in Registered Bottles.

	Register.	Number of Samples preserved with Salicylic Acid.
Beer,	George Bieberbach,	1
Ale,	Burke & Hastings,	1
Porter,	Burke & Hastings,	1
Ale,	Clinton House, P. H. Morrison, proprietor, Clinton, Mass.,	1
Porter,	Clinton House, P. H. Morrison, proprietor, Clinton, Mass.,	1
Ale,	S. F. Daly, Worcester, Mass.,	1
Ale,	Donahers, On the Square, Worcester, Mass.,	1
Porter,	Donahers, On the Square, Worcester, Mass.,	1
Beer,	M. T. Dwyer & Co , Clinton, Mass.,	1
Ale,	M. T. Dwyer & Co., Clinton, Mass.,	1
Beer,	Joseph Harper, Worcester, Mass.,	1
Porter,	John A. Hartigan, Worcester, Mass.,	1
Beer,	John Keegan & Co., Worcester, Mass.,	1
Ale,	W. C. Klebart, Webster, Mass.,	1
Ale,	P. M. Laughlin, Worcester, Mass.,	1
Porter,	P. M. Laughlin, Worcester, Mass.,	1
Ale,	M. A. Liller, Webster, Mass.,	2
Porter,	M. A. Liller, Webster, Mass.,	2
Beer,	J. W. McKean & Co., Worcester, Mass.,	2
Porter,	J. W. McKean & Co., Worcester, Mass ,	1
Ale,	T. F. Murphy, Hotel Columbia, Southbridge, Mass.,	1
Porter,	T. F. Murphy, Hotel Columbia, Southbridge, Mass.,	1
Ale,	M. F. O'Day, Worcester, Mass.,	1
Porter,	M. F. O'Day, Worcester, Mass.,	2
Ale,	Patrick O'Shea, Worcester, Mass.,	1
Porter,	Patrick O'Shea, Worcester, Mass.,	1
Beer,	D. Paul & Co., Spencer, Mass.,	1
Ale,	D. Paul & Co., Spencer, Mass.,	1
Ale,	Robinovits & Minian, Worcester, Mass.,	1
Summary,		33

Salicylic Acid in Malt Liquors. — While exceedingly small amounts of salicylic acid in beer and ale exercise a preservative action, it has commonly been found to be present to the extent from .02 to .03 of 1 per cent. Its presence in beer is usually readily shown by the ordinary methods in use. (See page 508.)

Sulphurous Acid in Malt Liquors. — This antiseptic is used by the brewer in the form of calcium or of sodium bisulphite. Samples of sodium bisulphite, both in solution and in crystal form, as taken from different breweries, have been examined in the laboratory.

For the detection of sulphurous acid, 100 c. c. of the sample of beer are first made acid with phosphoric acid and then subjected to distillation with steam, the distillate being received in a flask containing a measured amount (usually 15 c. c.) of tenth-normal iodine, an adapter being used to dip below the surface of the liquid in the receiver, to prevent loss. The process is continued until from 200 to 300 c. c. of distillate accumulate, and by titrating back with tenth-normal thiosulphate, the amount of iodine used up is calculated. By reason of the presence of certain substances natural in beer, a small amount of iodine is always reduced. The amount of iodine thus used up in pure beer should not exceed 2.5 c. c. of tenth-normal iodine, which would correspond in a pure beer to thirty milligrams of sodium sulphite. Samples found to contain added sulphite reduced the iodine to the extent of from 5.5 to 9.5 c. c. of tenth-normal iodine per 100 c. c. of the beer.

Fluoride in Beer. — Beer preservatives obtained from breweries and examined in the laboratory have included ammonium fluoride in crystals and in tablets. According to directions accompanying these commercial preservatives, the amount commonly used in beer would be about 1 part of ammonium fluoride in 50,000. For the detection of fluoride in beer, the method used is a modification of that of Blarez.[1] In carrying out this method, 150 c. c. of beer are taken from the thoroughly mixed sample and heated to boiling. To the boiling liquid are added 5 c. c. of a 10 per cent. solution of potassium sulphate and 10 c. c. of a 10 per cent. solution of barium acetate. By the aid of the centrifuge the precipitate is collected in a compact mass and washed upon a small filter, on which it is allowed to dry in the oven and afterwards transferred to a platinum crucible, first breaking up the precipitate and then adding the ash of the filter to the crucible.

A glass plate, preferably of the thin variety commonly used for lantern slide covers, is previously prepared in the following manner: It is first thoroughly cleaned and polished, and coated on one side by dipping while hot in a mixture of equal parts of Canauba wax and paraffine. A piece of thin asbestos paper, the same size as the plate, is punched with a circular hole a little smaller in diameter than the top of the crucible, and is soaked in the same mixture of Canauba wax and paraffine, after which it is firmly attached to the waxed surface of the plate by pressing the same firmly against it while hot, making sure that it is in

[1] Chemical News, 91, page 39, Jan. 29, 1905.

close contact at all points with the waxed plate. Near the middle of the opening in the asbestos a small cross or other distinctive mark is made through the wax with a sharp instrument, such as a pointed piece of wood or ivory, which will remove the wax and expose the surface of the glass when marked, without, however, scratching the glass.

A few drops of concentrated sulphuric acid are added to the residue in the crucible. The latter is covered with the waxed plate, with the asbestos in close contact with the top of the crucible in such a position that the marked portion is near the center of the crucible, the asbestos serving as a tight gasket to prevent the escape during the heating of the fumes of hydrofluoric acid, which thus act only on the exposed mark on the plate. In contact with the top of the waxed plate is then placed a cooling device, — a glass tube considerably larger in diameter than the crucible, the bottom of which is tightly covered with a thin sheet of pure rubber, and through which a constant current of cold water is allowed to pass. This cooling device is brought down firmly upon the top of the waxed plate, so that the rubber film is in close contact therewith, and the whole arrangement is lowered so that the crucible rests upon a heated electric stove. Here it remains for an hour, after which period the waxed plate is removed. The location of the distinguishing mark is first indicated on the back or unwaxed surface of the glass by means of gummed strips of paper, and then the wax layer with the asbestos is removed by heat or by a jet of steam and the plate is thoroughly cleaned with soft cloth. A distinct etching will be apparent on the glass where it was exposed, if fluoride were present. The asbestos may be used repeatedly.

Maple Products.

Twenty-nine samples of maple sugar and 81 of maple syrup were examined. Of these, 17 samples of sugar and 61 of syrup were found to be adulterated with varying amounts of refined cane sugar. Some of them, in fact, consisted wholly of this product.

The following is a list of the adulterated brands: —

Published Results of Analyses of Adulterated Brands of Maple Syrup.

Brand.	Manufacturer or Wholesaler.	Cane Sugar Syrup (Per Cent.).
Beaver,	American Pickling Company, Providence, R. I.,	70
Whitcher's,	Ayer Preserving Company, Ayer, Mass.,	95
– –	Blue Ridge Packing Company, N. Y.,	50
Gladstone,	Briggs Seaver Company, Boston, Mass.,	70
Old Homestead,	B. F. Chamberlain, Walpole, Mass.,	66

Published Results of Analyses of Adulterated Brands of Maple Syrup — Concluded.

Brand.	Manufacturer or Wholesaler.	Cane Sugar Syrup (Per Cent.).
– –	Coleman Co-operative Company, Quincy, Mass.,	95
Golden Vesta,	Cooper & Sisson, Providence, R. I.,	85
– –	E. T. Cowdrey & Co., Boston, Mass.,	75
Kite,	J. D. Dewell & Co., New Haven, Conn.,	80
Manhattan Club,	J. H. Folkins & Co., Boston, Mass.,	80
Metropolitan,	J. H. Folkins & Co., Boston, Mass.,	75
Green Mountain,	W. J. Lamb, Somerville, Mass.,	80
Pure,	W. J. Lamb, Somerville, Mass.,	80
Lawrence's,	Lawrence Brothers, Chelsea, Mass.,	100
Pure Vermont,	W. A. Little, Boston, Mass.,	90
Spindle City,	Mansfield, Whitam & Co., Lowell, Mass.,	75
Mohican,	Mohican Company, U. S. A.,	90
Golden Tree,	New England Maple Syrup Company, Boston, Mass.,	70
– –	New York Sugar Company, Montpelier, Vt.,	95
– –	M. O'Keefe, Boston, Mass.,	95
Pentucket,	– –	75
Pure,	E. D. Pettengill, Portland, Me.,	70
Perfection,	J. T. Pillman Preserving Company, Ayer, Mass.,	95
Merrimac,	Riverside Preserving Company, Lowell, Mass.,	85
Golden Label,	Simpson Spring Company, South Easton, Mass.,	85
Victor,	Simpson Spring Company, South Easton, Mass.,	75
Home City,	Springfield Pickling Company, Springfield, Mass.,	80
Sugar Notch,	C. M. Tice & Co., Boston, Mass.,	80
Gilt Edge,	J. C. Turner, Medford, Mass.,	50
Strictly Pure,	Vt. Maple Syrup Company, Stoweton, Vt.,	90
Maple Sap Syrup,	Frank Whitcher, Mansfield, Vt.,	95

Meat Products.

Under this head are included such foods as cured meat, Hamburg steak, mince meat, sausages and tripe, most of these products being examined for preservatives.

Hamburg Steak. — Sixty-nine samples were analyzed, of which 46 were found to be preserved with sodium sulphite, and without a label in conformance with the law.

Sodium sulphite is especially effective in preserving and intensifying the red color of chopped meat, which, untreated, very soon grows dull

in color. For the determination of sulphite in meat products, from 15 to 25 grams of the finely chopped sample are shaken with water, acidified with phosphoric acid, and subjected to distillation with steam in exactly the same manner as in the case of malt liquors. Here, as in the case of beer and ale, there are certain substances naturally present which exercise a reducing effect upon the iodine, and it is necessary to make due account of this in expressing results. Thus, unless there is a marked precipitate with barium chloride, as described below, it would be unsafe to condemn a sample containing as high as 0.1 of a per cent. of sodium sulphite, since a reduction equivalent to this has been found in pure meat. After titration of the distillate with tenth-normal thiosulphate, a few drops of barium chloride should be added and the solution shaken, whereupon a precipitate will form immediately if sulphite be present; but in the case of pure meat, even though there is a slight reduction of iodine, there should be no precipitate with barium chloride. Samples of meat condemned for containing added sulphite were found to yield from 0.14 per cent. up to 0.6 per cent. of the sodium salt.

On account of the decomposition of sodium sulphite on standing, the amount found in chopped meat grows less and less, until finally it disappears altogether, having gone over into the sulphate. It is for this reason that chemists who analyze sealed samples long after they are prepared sometimes fail to find it.

Sausages and Tripe. — Eighty samples of these products were examined for preservative; 35 contained boric acid. The method employed for the detection of boric acid is the same as that used for clams and oysters, and described elsewhere.

Molasses.

Thirty-five samples were examined, all of which were pure.

Oysters and Clams.

Sevety-seven samples were examined, of which 18 were found to contain boric acid. In testing for boric acid in such substances as oysters, sausages, tripe, etc., from 15 to 25 grams of the sample are made alkaline and burnt to an ash in a platinum dish. The ash is then treated with hot water, acidified slightly with hydrochloric acid and filtered, and the filtrate is evaporated to dryness in a porcelain dish over the waterbath. When dry, a few drops of tincture of turmeric are added and the dish is dried again on the bath. If after the second drying a deep red color is observable, turning olive-green to purple on application of ammonia, boric acid is indicated.

Spices.

Allspice. — Forty-three samples were examined, all of which were found to be pure.

Cassia. — Only 1 sample out of 62 examined were found to be adulterated. This sample contained at least 15 per cent. of exhausted ginger.

Cayenne. — Seventeen samples were examined, all of which were found to be pure.

Cloves. — Eighty-two samples were analyzed, 10 of which were adulterated. Adulterants found were exhausted ginger, added clove stems and exhausted cloves.

Ginger. — Three samples out of 67 analyzed were found to be adulterated; one contained an admixture of exhausted ginger, the other 2 samples were colored with turmeric.

Mace. — Eighteen samples were analyzed, of which 6 were found to consist largely of wild or Bombay mace.

Mustard. — Fifteen out of 93 samples examined were found to be adulterated. The usual adulterants, wheat, turmeric and miscellaneous weed seed, were found.

Nutmeg. — Seven samples were examined, all of which were found to be pure.

Pepper. — One hundred and thirty-seven samples were examined, 5 of which were adulterated by the addition of ground fruit stones, nut shells and added pepper shells.

Analyses of Adulterated Brands of Spices.

Spice.	Brand.	Manufacturer or Wholesaler.	Result of Analysis.
Cloves, .	Gold Medal, .	Importers' Branch, Boston, Mass., .	Admixture of exhausted cloves.
Cloves, .	Premium, . .	S. Scheuer & Sons, Paterson, N. J., .	Admixture of exhausted cloves.
Ginger, .	Gold Medal, .	Importers' Branch, Boston, Mass., .	Admixture of exhausted ginger.
Mace, .	Ambassador, .	Jno. Van Dyke & Co., New York, .	Large admixture of wild mace.
Mace, .	Gold Medal, .	Importers' Branch, Limited, New York,	Large admixture of wild mace.
Mace, .	- -	Logan, Johnson & Co., Boston, Mass.,	Large admixture of wild mace.
Mace, .	- -	H. A. Johnson & Co., Boston, Mass., .	Large admixture of wild mace.
Mustard,	Gold Medal, .	Importers' Branch, Limited, New York,	Excess of starch containing weed seed.
Mustard,	Victoria Mills, .	Atkins & Jones, London, . . .	Excess of starch containing weed seed.
Mustard,	- -	Bennet Sloan & Co., New York, . .	Admixture of turmeric.
Mustard,	Select Compound,	Tiger Mills, New York, ...	Chiefly wheat and turmeric.
Pepper, .	Select Compound,	Tiger Mills, New York, ...	Chiefly ground nutshells and fruit stones.
Pepper, .	Gold Medal, .	Importers' Branch, Limited, New York,	Excess of pepper shells.
Pepper, .	Royal Standard, .	Knickerbocker Mills, New York, .	Chiefly pepper shells.

Temperance Drinks.

Under this head are included various tonics and other beverages free from or low in alcohol, such as ginger ale, weak cider and the like, examined for the most part for preservatives. One hundred and twenty-seven samples of these beverages were analyzed, of which 26 contained benzoic or salicylic acid. Several brands of tonic were found to contain saccharin.

The following is a list of brands published as adulterated: —

Published Results of Analyses of Adulterated Temperance Drinks.

Brand.	Manufacturer or Wholesaler.	Antiseptic.
Duffy's Cider,	American Fruit Product Company, Rochester, N. Y.	Benzoic acid.
Champagne Cider,	Pureoxia Company, Boston, Mass.,	Salicylic acid.
Champagne Cider,	Sutlan & Fleming, Fitchburg, Mass.,	Salicylic acid.
Chelmsford Springs Ginger Ale,	Chelmsford Springs Company, Chelmsford, Mass.	Salicylic acid.
Cliquot Club Ginger Ale,	Cliquot Club Company, Millis, Mass.,	Benzoic acid.
U. S. Club Ginger Ale,	Phenix Nerve Beverage Company, Boston, Mass.	Salicylic acid.
U. S. Club Ginger Ale,	Puritan Carbonating Company, Millis, Mass.,	Salicylic acid.
Wheaton's Ginger Ale,	Hiram Wheaton & Sons, New Bedford, Mass.,	Salicylic acid.
Wheaton's Strawberry,	Hiram Wheaton & Sons, New Bedford, Mass.,	Salicylic acid.
Wheaton's Whaling City Punch,	Hiram Wheaton & Sons, New Bedford, Mass.,	Salicylic acid.
Imperial, "A Liquid Food,"	Otis S. Neale & Co., Boston, Mass.,	Salicylic acid.

Vinegar.

Fifty-three samples were examined, of which 23 did not conform to the Massachusetts standard.

Following is the summary of the analytical data of the 30 samples of cider vinegar found to be above the standard: —

Cider Vinegar above Standard, 30 Samples.

	Acid (Per Cent.).	Solids (Per Cent.).	Ash (Per Cent.).	Polarization (200 mm. Ventzke).	Alkalinity of Ash.[1]	Malic Acid Tests.	
						Lead Acetate (c.c.).	Calcium Chloride.
Highest,	5.52	2.60	.44	—3.5	35.0	1.4	Positive.
Lowest,	4.50	2.00	.26	—1.1	25.4	0.5	Positive.
Average,	4.79	2.28	.30	—2.4	31.3	0.84	Positive.

[1] Nine samples only.

Nineteen samples of cider vinegar below the standard stood as follows: —

Cider Vinegar below Standard, 19 Samples.

	Acid (Per Cent.).	Solids (Per Cent.).	Ash (Per Cent.).	Polarization (200 mm. Ventzke).	Alkalinity of Ash.[1]	Malic Acid Tests.	
						Lead Acetate (c.c.).	Calcium Chloride.
	5.12	1.26	.25	—1.4	-	0.6	Positive.
	4.94	1.68	.28	—1.0	-	0.8	Positive.
	4.90	1.80	.32	—2.3	-	-	Positive.
	4.65	1.93	.30	—1.8	23.8	0.7	Positive.
	4.59	1.48	.24	—1.9	-	0.7	Positive.
	4.58	1.96	.28	—1.1	27.0	0.7	Positive.
	4.46	2.05	.28	—3.1	31.8	0.2	Positive.
	4.46	2.48	.28	—2.0	-	0.4	Positive.
	4.42	1.90	.26	—2.4	28.8	0.4	Positive.
	4.42	1.89	.25	—2.5	-	0.8	Positive.
	4.38	2.68	.35	—3.7	-	-	Positive.
	4.36	2.28	.23	—2.7	-	0.6	Positive.
	4.35	2.98	.40	—3.2	-	-	Positive.
	4.29	2.84	.26	—2.4	25.0	0.7	Positive.
	4.26	2.40	.26	—1.8	-	0.7	Positive.
	4.26	2.05	.28	—1.7	20.0	0.7	Positive.
	4.22	2.17	.35	—1.2	-	-	Positive.
	3.96	2.67	.38	—1.7	-	1.6	Positive.
	3.84	2.17	.18	—2.1	-	1.0	Positive.
Average, . .	4.38	2.14	.28	—2.1	26.1	0.64	-

[1] Nine samples only.

Three vinegars declared to be adulterated show the following constants: —

Adulterated Vinegar, 3 Samples.

	Acid (Per Cent.).	Solids (Per Cent.).	Ash (Per Cent.).	Polarization (200 mm. Ventzke).	Alkalinity of Ash (c.c.).	Malic Acid Tests.		Color.
						Lead Acetate.	Calcium Chloride.	
Cider vinegar, .	4.78	0.77	.17	+0.2	-	Sl. ppt.	Sl. ppt.	Caramel.
Cider vinegar, .	4.28	2.00	.13	—1.6	12.6	Sl. ppt.	Sl. ppt.	-
Malt vinegar, .	4.78	0.20	-	-	-	-	-	Caramel.

Wine.

Twenty-six samples were examined, 1 of which was adulterated. This was labelled "Old Port Wine," and was the product of Shortell & Timmins of Boston. It contained commercial glucose, was artificially colored, and preserved with salicylic acid. This was sample No. 1 in the following table, which shows the analytical data on all the samples. The color of the precipitate with lead acetate in wines and fruit juices furnishes a useful clue to the nature of the fruit used, in the absence of artificial coloring matter, which, of course, would obscure the natural color of the precipitate.

Analyses of Wine.

	Per Cent. Alcohol by Weight.	Solids.	Ash.	Alkalinity of Ash of 100 Grams Wine c.c. $\frac{n}{10}$ Hcl.	Alkalinity of 1 Gram Ash c.c. $\frac{n}{10}$ Hcl.	Polarization. Mm. Direct.	Polarization. Ventzke Invert.	Lead Acetate Precipitate Color of.	Color.	Antiseptic.
Port, .	9.64	15.40	.37	8.65	42.8	+48.4	44.4	Red.	Coal tar.	Salicylic acid.
	16.23	11.99	.23	7.51	30.6	—0.1	—11.1	Brown.	Natural.	None.
	15.58	11.28	.21	9.00	41.5	—9.4	—14.2	Brown.	Natural.	None.
	15.33	12.77	.21	12.20	57.4	—12.5	—15.4	Brown.	Natural.	None.
	15.00	11.15	.29	12.69	43.1	—20.5	—20.6	Brown.	Natural.	None.
	17.00	15.14	.30	12.74	42.7	—26.7	—22.4	Brown.	Natural.	None.
	15.25	12.14	.24	11.30	47.6	—16.5	—17.2	Brown.	Natural.	None.
	16.00	12.90	.20	12.35	60.8	—16.5	—18.0	Brown.	Natural.	None.
Sherry, .	14.45	4.88	.20	7.75	39.5	+5.8	5.4	Yellow.	Natural.	None.
	13.69	5.27	.25	8.70	34.3	+6.3	5.9	Yellow.	Natural.	None.
	16.62	3.77	.20	9.00	45.0	—5.9	—5.9	Yellow.	Natural.	None.
	14.75	5.97	.18	12.38	68.8	8.2	6.7	Yellow.	Natural.	None.
	15.83	6.23	.21	11.99	56.5	—7.7	—10.3	Yellow.	Natural.	None.
	17.58	5.45	.27	15.41	56.2	—10.0	—10.0	Yellow.	Natural.	None.
	13.85	5.51	.18	7.62	43.3	7.7	7.2	Yellow.	Natural.	None.
	14.27	4.88	.20	5.35	27.3	7.0	7.2	Yellow.	Natural.	None.
Claret, .	9.14	2.17	.19	7.00	36.5	0.3	0.2	Greenish blue.	Natural.	None.
	9.14	3.51	.25	13.10	52.8	2.8	2.7	Greenish blue.	Natural.	None.
	10.46	2.79	.24	4.80	20.0	—0.2	—0.2	Greenish blue.	Natural.	None.
	9.79	3.02	.20	5.88	29.4	3.9	4.0	Greenish blue.	Natural.	None.
	9.86	2.84	.21	6.00	28.5	—0.3	—0.3	Greenish blue.	Natural.	None.
	9.00	2.40	-	-	-	0.0	0.0	Greenish blue.	Natural.	None.
	9.64	2.63	.23	10.70	46.7	—2.9	—1.2	Greenish blue.	Natural.	None.
	9.79	4.26	.21	6.70	31.6	9.6	9.6	Greenish blue.	Natural.	None.
	9.64	3.10	.24	7.50	31.6	—0.2	—0.2	Greenish blue.	Natural.	None.
Catawba,	15.83	17.12	.18	9.00	50.0	—18.5	—18.5	Yellow.	Natural.	None.

Canned Goods.

Fifty-six samples were examined, of which 15 were adulterated. Samples examined included devilled crabs, asparagus, beets, tomatoes and various canned soups for preservatives, all being found free.

Twelve brands of canned pears were examined for the presence of sulphurous acid, occasionally used as a bleaching agent, and none was found

to contain it, though 2 brands showed the presence of hydrogen sulphide, due, no doubt, to incipient decomposition.

Twenty-one brands of canned corn were examined for the presence of sulphurous acid, and 1 was found to contain 0.1 of a per cent. of sodium sulphite. The bleached appearance of this sample compared with the others indicated that the sulphite had been used for the purpose of whitening the product.

A large number of brands of canned peas were examined, 3 of which were pronounced adulterated, as being soaked. Seven brands of canned peas greened with copper were as follows: —

Published Results of Analyses of Canned Goods.

Variety.	Brand.	Manufacturer or Wholesaler.	Result of Analysis.
Peas,	Petits Pois, Extra Fins,	R. Monbadon, Paris,	Greened with copper.
Peas,	Petits Pois, Moyens,	A. Corbeille, Wespelaer,	Greened with copper.
Peas,	Petits Pois, Extra Fins,	G. Graemer, Malines, Belgique,	Greened with copper.
Peas,	Petits Pois, Extra Fins,	Pasque Fréres,	Greened with copper.
Peas,	Petits Pois, Extra Fins,	Tisserand & Fils, Wespelaer,	Greened with copper.
Peas,	Petits Pois, Extra Fins,	Du Pont et Cie, Bordeaux, France,	Greened with copper.
Peas,	Petits Pois, Fins,	Le Soliel, Malines,	Greened with copper.

Miscellaneous.

Samples of the following food products were examined and classed as genuine: —

Beer preservative (10 samples), cake (6 samples, examined for egg preservative and artificial coloring), coffee substitute (2 samples), compound lard (3 samples), grape juice (3 samples), salad dressing, and rum.

Baking Powder. — One brand "Morgan's Pride," an alum phosphate powder, was pronounced not in accordance with the law, bearing no formula.

Brandy Drops. — Two samples were found, the syrup in which contained more than 1 per cent. of alcohol by weight. These were sold to children under sixteen years of age, contrary to law.

"Cremo." — An ice cream foundation in four flavors: strawberry, vanilla, lemon and chocolate. The package contained eight envelopes, two of each flavor, containing powders alike in composition, and consisting of starch and gelatine slightly colored, but devoid of flavor.

Gluten. — Six samples were analyzed, 5 of which either did not conform to the statement on the package, or consisted entirely of ordinary flour.

Among the brands found not to be of good standard quality were the following: —

"Protasac" and "Glutosac," advertised to contain respectively 40 and 35 per cent. of proteids, both products of the Health Food Company of New York; and "Cold Blast Extra Flour," purporting to contain 22 per cent of proteids.

Maraschino Cherries. — One sample of this product, put out by A. T. Beattie & Co., importers, 168 Commercial Street, Boston, was found to be artificially colored with a coal-tar dye, preserved by benzoic acid, and containing but 0.21 of 1 per cent. of alcohol. It will be seen that the product had no maraschino to speak of in its composition.

Syrups. — Under this head are included samples of fruit syrup and of table syrup. Five in all were examined, one of which, The Oneida Pure Raspberry Syrup, made by the Oneida Company of Kennwood, N. Y., was found to be preserved with a large amount of salicylic acid.

Whiskey. — Four samples were examined, 2 of which did not conform to the standard. The latter included Cuckoo Pure Rye, the product of the Rex Distilling Company of Boston, and the Paul Jones Brand.

The Use of Preservatives in Food.

A more varied assortment of food products than usual has been found this year to contain artificial preservatives; and, in order to show at a glance just what foods are commonly treated with preservatives, the following table has been compiled: —

Table of Preserved Foods.

Character of Food.	Number of Samples examined.	Total Number preserved.	Number of Samples preserved with — Benzoic Acid.	Boric Acid.	Formaldehyde.	Fluorides.	Salicylic Acid.	Sulphites.	Per Cent. of Preserved Samples.
Clams,	40	9	–	9	–	–	–	–	22.5
Cream,	28	5	–	5	–	–	–	–	17.8
Mixed eggs,	27	5	–	–	5	–	–	–	18.5
Fruit syrups,	5	1	–	–	–	–	1	–	20.0
Jams and jellies,	52	8	8	–	–	–	–	–	15.4
Hamburg steak,	69	46	–	–	–	–	–	46	65.7
Ketchup,	21	12	12	–	–	–	–	–	57.2
Lime juice,[1]	17	17	1	–	–	–	8	12	100.0
Malt liquors,	312	118	–	–	–	23	92	3	37.9
Oysters,	37	9	–	9	–	–	–	–	24.3
Sausages,	68	27	–	27	–	–	–	–	39.7
Sweet cider,	14	7	5	–	–	–	2	–	50.0
Temperance drinks,	113	19	7	–	–	–	12	–	16.8
Tripe,	12	8	–	8	–	–	–	–	66.7
Wine,	26	1	–	–	–	–	1	–	3.8
	841	292	33	58	5	23	116	59	39.8

[1] Three samples of lime juice contained both salicylic and sulphurous acids.

No less than six antiseptic substances have been found this year in foods, not including saccharin, which, however, though possibly possessing antiseptic qualities, is used more for the purpose of an artificial sweetener. It should be said that the table includes only those foods in which the preservative was illegally used, since, of course, under the laws of the State, these added preservatives may be employed, if the package containing the food is properly labelled.

In past reports methods for the examination of various preservatives have been described. Under "Malt Liquors" in the present report is given the method used in this laboratory for the detection of fluorides, and under "Oysters" and "Clams" the latest method for the detection of boric acid in such products.

Salicylic and Benzoic Acids. — It is not at all difficult to detect these antiseptics by methods commonly in use when they are present in more than mere traces. Small amounts may, however, escape detection unless extra care be taken, especially in jams, jellies, ketchups and table sauces, and sometimes even in dark colored ales and porters, where the presence of deep coloring matters, either artificial or natural, may, by their solubility in ether, obscure the delicacy of the test or even obliterate it entirely. In such cases two methods of procedure may be adopted, one depending upon distillation, the other upon double extraction.

It has been found that, in the case of most food products, if 100 grams of the sample (mixed, if of heavy consistency, with a little water) be distilled with steam, 300 c. c. of distillate will contain practically all the salicylic or benzoic acid present. This distillate may be extracted in the ordinary manner with ether, and the salicylic or benzoic acid may be removed from the ether in a separatory funnel by means of dilute ammonia, or it may be evaporated to small bulk, after making alkaline. The final test is made in either case with ferric chloride in the usual manner on the final solution concentrated to a few drops, which, of course, should be neutral, and in the case of benzoic acid should contain the latter in the form of an alkaline benzoate.

By the method of double extraction, the acidified sample is shaken with ether, and then the antiseptic is extracted from the ether by dilute ammonia. On evaporating the latter solution to a few drops (thus removing the free ammonia), and on further testing with ferric chloride, if the test is obscured by reason of the presence of coloring matter in the residue, the latter is dissolved in a few drops of acidified water, and the solution is shaken again with petroleum ether in the separatory funnel. The second, or petroleum ether extract, is then evaporated to dryness, and this is tested in the usual manner for salicylic or benzoic acid, mak-

ing sure that in the case of benzoic acid, as before, it is present as an alkaline benzoate. In nearly every case the second extract will be found to be entirely free from obscuring colors.

Summary of Food Statistics, exclusive of Milk.

	Genuine.	Adulterated.	Total.		Genuine.	Adulterated.	Total.
Allspice,	43	-	43	Jams and jellies,	31	21	52
Butter,	100	5	105	Ketchup,	9	12	21
Canned goods,	51	15	66	Lard,	21	3	24
Cassia,	61	1	62	Lime juice,	-	17	17
Cayenne,	17	-	17	Mace,	12	6	18
Cheese,	17	-	17	Malt liquors,	194	118	312
Clams and oysters,	59	18	77	Maple sugar,	6	17	23
Cloves,	72	10	82	Maple syrup,	20	61	81
Cocoa,	13	4	17	Meat products:—			
Coffee,	37	6	43	Cured meats,	5	-	5
Condensed milk,	21	2	23	Hamburg steak,	23	46	69
Confectionery,	24	1	25	Mince meat,	3	-	3
Cream,	21	7	28	Sausages,	41	27	68
Cream of tartar,	110	6	116	Tripe,	4	8	12
Eggs,	22	5	27	Miscellaneous,	40	23	63
Flavoring extracts:—				Molasses,	35	-	35
Jamaica ginger,	-	2	2	Mustard,	78	15	93
Lemon,	17	28	45	Nutmeg,	7	-	7
Nutmeg,	1	-	1	Pepper,	132	5	137
Orange,	1	1	2	Tea,	12	-	12
Peppermint,	1	1	2	Temperance drinks,	101	26	127
Vanilla,	22	7	29	Vinegar,	30	23	53
Ginger,	64	3	67	Wine,	25	1	26
Honey,	31	1	32	Totals,	1,634	542	2,176

Drugs.

A marked improvement in the quality of the drugs examined during the present year is apparent, due largely to increased prosecutions. Much the same classes of drugs have been examined as in past years.

The general quality and variety of drugs examined are shown in the summarized table, on page 514.

Calx Chlorata. — As usual, most of the samples of chlorinated lime examined were found to be below the standard of 35 per cent. available chlorine. The brands found to be low in strength were: the "Acme" and "Hudson," both made by A. Mendleson & Son, Albany, N. Y.; the "Lion" brand of James A. Blanchard, New York; the "Black Diamond" of Archibald & Sons; the "Crescent" brand of Hirston Company, New York; the "Eclipse" of N. J. & H. J. Meyer Company, New York; and the "Royal" of Legget & Bro., New York.

Capsicum. — Out of 91 samples examined, only 3 were found to be adulterated. These contained varying admixtures of corn starch. As showing marked improvement in the quality of this drug during recent years, it may be said that in 1900, 30 per cent. of the samples examined were found to be adulterated; in 1901, 28 per cent.; in 1902, 12.6 per cent.; in 1903, 13 per cent.; in 1904, 7.3 per cent.; while in the present year only about 3 per cent. of those examined were adulterated.

Extractum Glycyrrhizæ. — Of 18 samples examined, 13 were found to contain wheat or corn starch. It is claimed by manufacturers that cereal starch is essential in the preparation of the powdered extract of licorice, to prevent caking together; but in view of the fact that 5 samples were found to be free from starch, and were of excellent quality and consistency, one may regard the addition of foreign starch as unnecessary.

Extractum Zingiberis Fluidum. — Of 18 samples examined, 8 were found not to conform to the standard, being in fact weak extracts of ginger, low in alcohol. U. S. P. extract of ginger should contain at least 75 per cent. by weight of alcohol, and at least 6.5 per cent. of total solids, which consist chiefly of essential oil and the oleoresins. Indeed, the entire medicinal value of ginger extract is inherent in the essential oil and oleoresins, which substances are entirely wanting in the low extracts, because they are insoluble in weak alcohol. The adulterated varieties contain from 20 to 30 per cent. by weight of alcohol, and, as a rule, a small fraction of 1 per cent. of total solids.

It is in the highest degree fraudulent to substitute for the fluid extract of the Pharmacopœia the so-called "soluble extract of ginger," which does not appear in the Pharmacopœia or the Dispensatory, and has absolutely no medicinal value. The "soluble extract" is primarily intended for use as a flavor in syrups and beverages, and is also put out largely in small flasks as a beverage in itself, on account of the alcohol which it contains.

Oleum Limonis. — Half the samples of lemon oil examined during the year failed to conform to the standard. One sample sold at Woodward's Cut-price Drug Store in Boston contained no lemon oil whatever,

consisting of dilute alcohol and sugar, and containing 10.5 per cent. of total solids.

Oleum Morrhuæ. — As a standard for pure cod liver oil, the following table, showing the refraction at different temperatures, has been prepared by H. C. Lythgoe, based on the examination of a number of oils of undoubted purity. Any variation exceeding 1.3 from the readings of the table is sufficient for submitting the sample to further examination as being suspicious.

Refraction of Cod Liver Oil.

Temperature (Degrees C.).	Butyro-refractometer Reading.	n_D.	Temperature (Degrees C.).	Butyro-refractometer Reading.	n_D.
35.0	71.4	1.4732	25.0	77.5	1.4769
34.5	71.8	1.4734	24.5	77.8	1.4771
34.0	72.1	1.4736	24.0	78.1	1.4773
33.5	72.4	1.4738	23.5	78.4	1.4774
33.0	72.7	1.4740	23.0	78.7	1.4776
32.5	73.0	1.4742	22.5	79.1	1.4778
32.0	73.2	1.4743	22.0	79.4	1.4780
31.5	73.5	1.4745	21.5	79.7	1.4781
31.0	73.8	1.4747	21.0	80.0	1.4783
30.5	74.1	1.4749	20.5	80.3	1.4785
30.0	74.4	1.4751	20.0	80.6	1.4787
29.5	74.7	1.4753	19.5	81.0	1.4789
29.0	75.0	1.4754	19.0	81.3	1.4791
28.5	75.3	1.4756	18.5	81.6	1.4792
28.0	75.6	1.4758	18.0	81.9	1.4794
27.5	75.9	1.4760	17.5	82.2	1.4796
27.0	76.2	1.4762	17.0	82.5	1.4798
26.5	76.5	1.4763	16.5	82.9	1.4800
26.0	76.8	1.4765	16.0	83.2	1.4802
25.5	77.2	1.4767	15.5	83.5	1.4803
25.0	77.5	1.4769	15.0	83.8	1.4805

Oleum Olivæ. — Five samples of olive oil out of 35 examined were found to be badly adulterated. Two of these consisted almost entirely of cotton-seed oil. One was chiefly a petroleum spindle oil. This was sold for olive oil at Fallon's Pharmacy, Hyde Park. Another sample contained a large admixture of peanut oil. Still another, sold at Levasseurs' Pharmacy, Worcester, contained 50 per cent. of sesame oil.

Oleum Ricini. — From a large number of samples of pure castor oil, Mr. H. C. Lythgoe has prepared the following readings on the butyro-refractometer for each half degree from 15 to 35 degrees C., together with the corresponding values of index of refraction.[1]

Refraction of Castor Oil.

Temperature (Degrees C.).	Butyro-refractometer Reading.	n_D.	Temperature (Degrees C.).	Butyro-refractometer Reading.	n_D.
35.0	72.0	1.4736	25.0	78.1	1.4773
34.5	72.3	1.4738	24.5	78.4	1.4775
34.0	72.6	1.4740	24.0	78.7	1.4776
33.5	72.9	1.4742	23.5	79.0	1.4778
33.0	73.2	1.4744	23.0	79.3	1.4780
32.5	73.5	1.4745	22.5	79.6	1.4782
32.0	73.8	1.4747	22.0	79.9	1.4784
31.5	74.1	1.4749	21.5	80.2	1.4785
31.0	74.4	1.4751	21.0	80.6	1.4787
30.5	74.7	1.4753	20.5	80.9	1.4789
30.0	75.0	1.4755	20.0	81.2	1.4791
29.5	75.3	1.4756	19.5	81.5	1.4793
29.0	75.6	1.4758	19.0	81.8	1.4795
28.5	75.9	1.4760	18.5	82.1	1.4797
28.0	76.2	1.4762	18.0	82.5	1.4798
27.5	76.5	1.4764	17.5	82.8	1.4800
27.0	76.9	1.4766	17.0	83.2	1.4802
26.5	77.2	1.4768	16.5	83.5	1.4804
26.0	77.5	1.4769	16.0	83.9	1.4806
25.5	77.8	1.4771	15.5	84.2	1.4808
25.0	78.1	1.4773	15.0	84.5	1.4809

One sample of castor oil, put out by the Forest City Extract Company of Portland, Me., was found to contain 50 per cent. of cotton-seed oil. The spurious nature of this sample was pointed out by the refractometer and subsequently was confirmed by other tests, as shown as follows: —

	Castor Oil.	Adulterated Oil.	Cotton-seed Oil.
Butyro-refractometer reading at 20°,	81.2	75.0	70.9
Polarization, ° Ventzke,	24.1	10.5	—0.4
Specific gravity at 15°,	0.961	0.9378	0.923
Iodine number (Hanus),	85.0	99.4	109.0
Halphen test,	-	Red.	Red.

Pilulæ Ferri Carbonatis. — The single sample of Blaud's Pills analyzed, the product of the Independent Pharmaceutical Company of Worcester, was found to contain 0.12 gram of ferrous sulphate per pill. The Pharmacopœia calls for 0.16 gram.

Sodii Boras. — Three out of 7 samples of borax examined were adulterated. One of the adulterated brands, the "Eclipse Best Refined Powdered Borax," having a formula "60 per cent. sodium biborate, 40 per

[1] Journal American Chemical Society, June 27, 1905, p. 887.

cent. sodium bicarbonate," was found to contain no borax whatever. It consisted entirely of bicarbonate.

Spiritus Camphoræ. — Eight samples out of 25 were found to be adulterated, being weak in camphor.

The following table shows the polarization and index of refraction of varying strengths of camphor, dissolved in strong alcohol. Abnormally low indices of refraction would indicate presence of wood alcohol.

Spiritus Camphoræ.

Per Cent. of U. S. P. strength.	Polarization (200 mm. Tube).	Refraction if not watered.		Per Cent. of U. S. P. strength.	Polarization (200 mm. Tube).	Refraction if not watered.	
		n_D 20°.	n_D 35°.			n_D 20°.	n_D 35°.
0,[1] . .	0.0	1.3645	1.3575	55, . .	12.6	1.3703	1.3633
5, . .	1.0	1.3650	1.3580	60, . .	13.8	1.3708	1.3638
10, . .	2.1	1.3655	1.3585	65, . .	14.9	1.3714	1.3644
15, . .	3.2	1.3660	1.3590	70, . .	16.0	1.3720	1.3650
20, . .	4.4	1.3665	1.3596	75, . .	17.3	1.3725	1.3655
25, . .	5.4	1.3674	1.3601	80, . .	18.7	1.3730	1.3660
30, . .	6.5	1.3676	1.3606	85, . .	19.8	1.3735	1.3665
35, . .	7.7	1.3681	1.3611	90, . .	21.0	1.3740	1.3670
0, . .	8.9	1.3687	1.3617	95, . .	22.5	1.3745	1.3675
45, . .	10.2	1.3692	1.3622	U. S. P., .	24.0	1.3750	1.3680
50, . .	11.4	1.3698	1.3628				

[1] Strong alcohol.

Sulphur Præcipitatum. — Nine samples out of 14 examined were badly adulterated with calcium sulphate. The worst sample contained 59.34 per cent. of this adulterant.

Tinctura Iodi. — Ninety-seven samples out of 173 were low in strength, as follows: —

2 samples were above the United States pharmacopœial strength.
76 " " United States pharmacopœial strength.
14 " " between 90 and 95 per cent. of the United States pharmacopœial strength.
32 " " " 80 " 90 " " " " " "
26 " " " 70 " 80 " " " " " "
11 " " " 60 " 70 " " " " " "
5 " " " 50 " 60 " " " " " "
3 " " " 40 " 50 " " " " " "
2 " " " 30 " 40 " " " " " "
2 " " " 20 " 30 " " " " " "

Here, as in the case of other standard drugs analyzed, an improvement in quality is noted. Thus, in 1904 the average strength of all the samples examined was 76 per cent. of that prescribed by the Pharmacopœia, while during the present year the average strength of those examined was 90 per cent.

Miscellaneous Drugs.

Under this head are included quinine pills (5 samples), Dover's powders and Epsom salts.

Among the patent medicines examined for alcohol were Marlowe's Cola Wine, an Elixir for women, "a safe, simple tonic," put out by the Marlowe Manufacturing Company of New York and Boston, containing 18.68 per cent. by volume of alcohol; and Peruna, containing 27.49 per cent. of alcohol by volume.

Summary of Drug Statistics.

	Genuine.	Adulterated.	Total.		Genuine.	Adulterated.	Total.
Alcohol,	5	–	5	Oleum ricini,	17	1	18
Aqua ammoniæ fortis,	1	–	1	Opii pulvis,	2	–	2
Aqua destillata,	2	3	5	Pillulæ ferri carbonatis,	–	1	1
Calx chlorata,	2	12	14	Potassii bitartras,	6	–	6
Capsicum,	88	3	91	Potassii iodidum,	3	–	3
Caryophyllus,	1	–	1	Pulvis glycyrrhizæ compositus,	8	–	8
Cera alba,	–	1	1	Quininæ sulphas,	4	–	4
Cera flava,	11	4	15	Sodii benzoas,	5	–	5
Chloroform,	8	–	8	Sodii boras,	4	3	7
Cinnamomum cassia,	1	–	1	Sodii iodidum,	5	–	5
Extractum glycyrrhizæ,	5	13	18	Sodii phosphas,	18	2	20
Extractum zingiberis fluidum,	9	8	17	Spiritus ætheris nitrosi,	1	–	1
Ferri et quininæ citras,	1	–	1	Spiritus camphoræ,	17	8	25
Ferrum reductum,	10	–	10	Spiritus frumenti,	2	6	8
Gin,	–	2	2	Spiritus menthæ piperitæ,	5	–	5
Glycerinum,	64	–	64	Spiritus myrciæ,	1	8	9
Liquor calcis,	1	–	1	Sulphur lotum,	14	–	14
Macis,	1	2	3	Sulphur præcipitatum,	5	9	14
Magnesii sulphas,	1	–	1	Syrupus,	1	1	2
Miscellaneous,	33	2	35	Tinctura iodi,	76	97	173
Oleum amygdalæ amaræ,	1	–	1	Tinctura nucis vomicæ,	–	2	2
Oleum caryophylli,	11	2	13	Tinctura opii,	2	2	4
Oleum cinnamomi,	8	6	14	Tinctura zingiberis,	3	–	3
Oleum gaultheriæ,	9	–	9	Unguentum hydrargyri,	1	6	7
Oleum limonis,	9	9	18	Unguentum zinci oxidi,	12	7	19
Oleum menthæ piperitæ,	5	–	5				
Oleum morrhuæ,	9	1	10	Summary,	538	226	764
Oleum olivæ,	30	5	35				

General Summary.

	Genuine.	Adulterated.	Total.
Milk,	1,841	1,323	3,164
Foods, exclusive of milk,	1,634	542	2,176
Drugs,	538	226	764
Total,	4,013	2,091	6,104

Inspection of Liquors.

Police officers of 24 cities and towns have availed themselves this year of the privilege of sending liquors to the Board of Health for examination as to the amount of alcohol, under the provisions of chapter 110 of the Acts of 1902.

From time to time samples of liquor are sent in by town officers with the request to analyze for impurities, poisons or adulterants. It should be stated again that the sole purpose of the above act is to enable town authorities to ascertain from its alcoholic content whether or not a beverage may be legally sold without a liquor license, and that no provision is made for the further analysis of the liquor, beyond the determination of its alcohol.

When it is remembered that liquors, especially the stronger kinds, found to be adulterated are so declared, as a rule, because they contain added water or sugar or color, and never because of added poisons or anything more powerful than the natural alcohols, the fear of injury from the adulteration of liquors should cease.

The following summary shows the localities from which liquors were sent, and the general character of the samples: —

Summary of Liquor Statistics.

	Number of Samples of Wine.	Number of Samples of Cider.	Number of Samples of Beer.	Number of Samples of Whiskey.	Number and Character of Miscellaneous Samples.
Arlington,	3	3	–	–	–
Ashland,	–	–	1	–	–
Boston,	–	–	18	–	7 Chinese liquors. 5 alcohols.
Brockton,	1	–	2	1	
Cambridge,	–	4	–	–	–
Danvers,	–	1	–	–	–
Fall River,	–	–	1	–	–
Gardner,	–	2	–	–	–
Littleton,	1	2	–	–	–
Lowell,	–	–	1	–	–
Lynn,	–	–	–	1	–
Marlborough,	–	–	3	–	–
Norwood,	–	3	–	–	–
Peabody,	–	2	–	–	–
Plymouth,	–	2	1	–	9 "tonics."
Randolph,	1	1	–	–	–
Revere,	–	–	6	–	–
Rockland,	–	1	–	–	2 "malt extracts."
Salem,	5	6	4	–	1 arrack.
Swansea,	–	–	1	–	–
Townsend,	–	–	1	–	–
Wakefield,	–	1	–	–	–
Waltham,	–	8	1	–	–
Wareham,	13	–	–	–	–
Total,	24	36	40	2	24

As near as may be judged, about 80 per cent. of the above samples were prosecuted in court, in most cases the analyst's certificate being

accepted as evidence. Personal attendance of the analyst was, however, required in the lower courts of Ayer, Boston, Cambridge, Chelsea and Wareham, for the prosecution of liquor cases, and at least a dozen times in the Superior Court of Suffolk County.

Among the liquors brought in by Boston officers were 7 samples of Chinese distilled liquors, seized from Chinese merchants in Harrison Avenue. These liquors were delivered as originally imported, in odd-shaped jugs and demijohns, covered with Chinese inscriptions. The beverages themselves were peculiarly oriental, being evidently made from rice and other native products, and in no way resembled the distilled liquors in common use in this country. Among them was a "Chinese wine," containing 52.3 per cent. alcohol by volume.

Following are analytical data of 4 of these Chinese liquors, to which special attention was paid on account of their peculiar nature: —

Inspection Number.	Specific Gravity at 15°.	Alcohol (Per Cent. by Volume).	Extract (Per Cent.).	Ash (Per Cent.).	Polarization (200 mm.).		Precipitate with Lead Acetate.	Immersion Refractometer Reading of Distillate at 20°.
					Direct.	Invert.		
579	0.9512	52.29	7.01	0.02	31.8	—3.8	Slight.	86.0
580	0.9595	51.53	8.80	0.01	27.2	—6.2	Slight.	84.8
581	1.0303	25.47	14.95	0.27	26.9	20.9	Heavy.	52.1
582	0.9973	24.68	6.61	0.12	18.0	—5.1	Fair.	51.3

A sample of "arrack" seized in Salem was found to contain 41 per cent. of alcohol.

Five samples of strong alcohol, used for beverages, were seized from as many Brockton dealers, and were found to contain 93.49 per cent., 90.58 per cent., 83.25 per cent., 94 per cent. and 93.49 per cent. of alcohol by volume.

Respectfully submitted,

ALBERT E. LEACH,
Analyst.

INSPECTION OF DAIRIES.

By the Secretary of the Board.

INSPECTION OF DAIRIES.

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The causal relation of unclean milk to infantile death-rates is one of the established facts of preventive medicine; and experience has shown, both in this country and abroad, that improvement in the sanitary conditions of milk production, handling, storage, transportation and distribution is followed by such marked diminution in the loss of infant life as to make it the imperative duty of public health authorities to give to this much-neglected subject the fullest possible attention. Laws against fraudulent adulteration of milk have been long in existence in most parts of the civilized world, but until very recently the more important question of wholesomeness has been confined within the limits of academic discussion, and only in a small number of cities and towns have regulations been made by local authorities, having no power of supervision beyond the limits of their respective communities. In no State in the Union and in no foreign country has the central authority thus far enacted and enforced the strict legislation necessary for the protection of the public health against the consequences of the use of milk contaminated by the exciting causes of infective diseases, especially of cholera infantum, at the place of production and during storage, transportation and sale. These causes are in part inherent in the cow (garget, tuberculosis of the udder, etc.), but to a far greater extent they gain access to the milk, therein to multiply, through preventable filth and dust. The production of clean, wholesome milk is dependent upon the maintenance of health in the cow; upon cleanliness of the cow, the cow stable, the milkers and the utensils employed; and upon the methods followed in cooling, handling, storage, transportation and distribution. Clean milk cannot be produced from diseased cows nor from cows encrusted with their own excrement, which in the process of milking must, to some extent at least, become dislodged as fine dust or in large particles and fall into the milking pail; and, even though the larger particles and hairs be removed in the process of straining, the harm has been done. It cannot be produced, even from clean cows, if the milking be done by milkers with unclean hands and unclean clothing, from which the infective organisms may be communicated to

the contents of the pail. It cannot be produced where the milking pails, cans and other utensils are not kept in a scrupulously clean condition, and protected from bacteria-laden dust particles. Even under the most perfect sanitary conditions complete exclusion of the various fermentative organisms is impossible, but their almost inconceivably rapid multiplication can be prevented by rapid cooling of the milk and maintenance of a low temperature thereafter, since warmth is the one most important favoring condition for growth. Therefore, proper and efficient methods and means of cooling and storage are most essential.

Since milk is very sensitive to odors, which it very readily absorbs to such an extent as to affect its taste, the proximity of pigs, horses, swill, stored manure and other sources of foul odors is inconsistent with prime quality.

The physical condition of the cow having a direct influence upon the quality of her milk, the conditions of the stable as to ventilation, light and other influences affecting health should receive a generous measure of attention.

It will be seen, therefore, that the production of milk fit for human, and especially infant, consumption, requires proper housing of healthy stock, general cleanliness and careful handling.

Recognizing the well-demonstrated importance of an improved milk supply in its relation to the public health, the Board, acting under its general authority, began, on March 1, 1905, a systematic investigation of dairies and the conditions under which milk is produced for public sale. As stated in the first part of this report, the examination embraces an inquiry into the health and condition of cleanliness of the cows, the sanitary condition of the stables, the water supply, the methods of drawing, cooling, handling and transportation, and other matters germane to the subject.

A separate report is made on each dairy by the inspector to the secretary of the Board, who determines what changes, if any, in conditions or methods are desirable, and communicates his suggestions directly or indirectly to the person responsible in each instance. The investigation demonstrated from the start its necessity, for a condition of affairs was disclosed which is not creditable to the Commonwealth. It is true that in most cases the objectionable conditions reported were susceptible of improvement without the expenditure of money, and without involving anything more than ordinary care in the matter of common cleanliness; but in many instances the conditions which obtained were found to be most revolting in character.

The worst existing conditions were not, as might be supposed, found always in the poorer country districts, but often within the limits of

cities. One of the worst places visited was situated within five miles of the State House, and presented the following conditions: In a barn with 9,000 cubic feet of air space, with no cellar, and inadequately lighted, were found 3 horses and 14 filthy cows, the latter being fed on brewers' grains, rotting potatoes and a little grain. The store of potatoes was kept in an adjoining yard, which could not be crossed except by walking through mud and filth nearly 6 inches in depth. In one corner of this yard was an equally filthy pen containing ducks. The liquid manure and other drainage of the barn and yard were conducted in shallow ditches to a small creek, which constituted the sole water supply of the place for watering the stock and washing the milk pails, cans and glass jars used in delivery. The room in which the milk was cooled and handled was thoroughly in keeping with its surroundings, being filthy in all particulars, and exceedingly foul-smelling. The attention of the local boards of health of the cities in which this milk was being sold was called to the impossibility of producing clean and wholesome milk in such surroundings.

Numerous cases, equally bad in some respects, less so in others, and worse in still others, have been reported in various parts of the area covered thus far by the inspector.

During the seven months ended September 30, 2,151 dairies were examined. The geographical distribution of these dairies is shown in the following table, which includes only those towns in which at least 10 places were inspected: —

	Number of Dairies found to be without Objectionable Feature.	Number of Dairies where One or More Objectionable Features were observed.	Total Number of Dairies examined.
Acton,	34	36	70
Ashland,	3	10	13
Bedford,	17	30	47
Bellingham,	6	8	14
Berlin,	11	26	37
Billerica,	16	48	64
Bolton,	13	53	66
Boxborough,	2	39	41
Boylston,	3	31	34
Carlisle,	10	33	43
Chelmsford,	14	69	83
Concord,	11	65	76
Framingham,	18	28	46

	Number of Dairies found to be without Objectionable Feature.	Number of Dairies where One or More Objectionable Features were observed.	Total Number of Dairies examined.
Franklin,	9	21	30
Groton,	6	32	38
Harvard,	12	88	100
Holliston,	19	39	58
Hopkinton,	6	39	45
Hubbardston,	5	22	27
Lancaster,	3	24	27
Lexington,	5	21	26
Lincoln,	9	31	40
Littleton,	21	51	72
Marlborough,	7	53	60
Medway,	0	20	20
Mendon,	6	11	17
Milford,	3	12	15
Millis,	0	20	20
Norfolk,	4	6	10
Northborough,	13	65	78
North Reading,	1	9	10
Pepperell,	7	22	29
Princeton,	5	15	20
Sherborn,	17	17	34
Shirley,	2	16	18
Shrewsbury,	7	83	90
Southborough,	5	58	63
Sterling,	18	93	111
Stow,	4	32	36
Sudbury,	9	60	69
Townsend,	5	9	14
Wayland,	3	25	28
Westborough,	17	68	85
West Boylston,	5	33	38
Westfield,	0	18	18
Westford,	8	46	54
Weston,	12	21	33
Miscellaneous,	20	64	84
	431	1,720	2,151

Under "Miscellaneous" are included dairies situated in the following cities and towns; but, inasmuch as the number visited in any one place is small, it is deemed best not to present the details at this time.

Agawam.	Greenwood.	Needham.
Arlington.	Hingham.	Randolph.
Ashby.	Hudson.	Southwick.
Attleborough.	Ipswich.	Springfield.
Ayer.	Longmeadow.	Tyngsborough.
Burlington.	Lunenburg.	Upton.
Cambridge.	Mason (New Hampshire).	Watertown.
Clinton.	Maynard.	West Springfield.
Dunstable.	Medfield.	Winchester.
Enfield (Connecticut).	Methuen.	Woburn.
Everett.	Natick.	

In 20 of these 84 places no objectionable conditions were found. Most of these 84 farms were visited for special reasons, and not in the course of systematic inspection.

As will be seen from the above table, out of a total of 2,151 dairies, 431 were reported as being without objectionable conditions, and 1,720, or 80 per cent., as meriting some attention looking to improvement in existing conditions. In the letters which were sent concerning the latter, attention was called to a total of 4,793 defects, the nature of which are set forth in the following analysis: —

Condition of Cows.

In cases where it was possible to do so, the cows were examined as to condition of health and as to condition of cleanliness, but during the warmer months, when the cows were out, this part of the inspection necessarily could not be pursued. Of the cows examined indoors, but 46 were found to be tuberculous; 20 were afflicted with garget to such an extent that the milk contained large amounts of pus; and 10 had retained fœtal membranes, with consequent purulent discharge which reached the udder. The attention of the Chief of the Cattle Bureau was called in each case to the existence of tuberculosis, and in all of the above cases the owners were warned to withhold the milk of the particular animals from the market, attention being called at the same time to the fact that the sale of milk from a diseased animal is punishable by fine.

The majority of herds observed were found to be kept in a condition far removed from cleanliness. In some cases an entire herd would be found to be encrusted, chiefly on the hinder parts, with wet and dry

excrement. In many barns the conditions were found to be such that a cow, however clean she might be on introduction, could not fail to be dirty to an objectionable extent within twenty-four hours. As though the natural opportunities afforded for becoming filthy were not already ample, in no fewer than 182 cases was horse manure employed as a bedding material.

Enquiry developed the fact that on most farms not only are the cows never groomed, but usually not even their udders are wiped off before the process of milking is begun.

Condition of Stables.

Light. — It is remarkable to what extent the importance of light, both as a purifying agent and as a necessary condition to health and well-being of cows, is neglected. In a large number of the cow stables no provision whatever existed for the admission of light, the open door being its only point of ingress. In some instances what was formerly a glass window had been replaced by a board, or the glass, having been broken, had been replaced with wood or a bundle of straw or other material, to prevent draft. Cases were found where the single window provided had lost its utility through being obstructed by accumulated manure. In many cases an insufficient number of windows, or a sufficiently large number of windows, of inadequate size, were found. The total number of suggestions sent concerning improvement in lighting was 536.

Ventilation. — Contrary to expectation, the proportion of ill-ventilated barns was found to be small. In only 79 cases was it found necessary to advise the provision of better facilities for removal of foul air and admission of fresh air, and in only 5 instances were the cattle found to be so crowded as to have a far too small allowance of cubic space per head.

General Cleanliness. — In the great majority of stables general uncleanliness was the rule. Obviously, the parts most likely to be unclean were the platforms and the spaces back of the cows. In very many cases, however, the condition of every part of the barn was one of filth.

Of the 1,720 stables which showed defects of one kind or another, no fewer than 1,437 were in need of general cleaning and whitewashing. Other objectionable conditions which were made the subject of correspondence were 106 cases of accumulated manure back of or near the cows; 17 cases of accumulation of liquid manure in depressions in the barn floor; 3 cases of absolute blocking of windows with manure; 132 cases of proximity of open privies to the tie-up; 7 cases of deposits of human excrement over the floors; 3 cases of presence of exceedingly filthy calf pens; 2 cases of use of the tie-up for slaughtering purposes,

the blood and refuse being improperly cared for; 39 cases of floors so far out of repair as to preclude all chance of cleanliness; and 14 cases of need of a proper system of drainage.

In not a few instances, while the cow barn and all its appointments may be maintained in a properly clean condition, its cellar appears to be regarded as of little importance; but a dirty cellar, especially in summer, when insect life is active, may be quite as prolific of trouble as a dirty tie-up. In 255 cases the owner was requested to provide some means for the suitable draining of the cellar, and in 284 cases to remove the accumulated manure. In one instance the cellar contained the accumulation of three years, and in another of fifteen months.

In no first-class dairy would the keeping of other animals than those which ordinarily belong there be tolerated; but in many of our cow barns it appears to be regarded as not objectionable to stable horses, to fatten pigs, and to allow sheep, goats and fowls to wander unrestrained. Letters were sent to 272 individuals, requesting the separation of the horses from the cow tie-up by means of suitable partitions; and to 227, requesting the removal of swine and their pens to a proper distance. In 47 cases the cow barn was used for the storage of ordinary city swill, and in one case this material was stored wholesale, the owner being a city scavenger, and dealing in swill, as merchandise, with his neighbors. In all these cases, and in 31 in which fermenting and rotting brewers' grains were stored, 3 in which fertilizers were stored, 16 where rotten fruit and vegetables were scattered about, and 8 in which dead fowl were undergoing decomposition, the removal of all offensive material was directed. Letters were sent to 14 individuals, suggesting that sheep, goats or poultry be confined, and not allowed access to the tie-ups.

Condition of Cow Yards. — Partly due to carelessness and partly to natural difficulties in the way of drainage, it happens not infrequently that the cow yard, which should be at least a proper place for outdoor exercise of the stock if desired, is converted into a slough from which the gaseous products of decomposition of liquid and solid manure are given off in such amounts as to be perceptible hundreds of feet distant. In 52 cases the owner was requested to clean his cow yard; and in 149 to drain off the pools of liquid, foul-smelling manure, and to fill in the depressions and make the place less of a public and private nuisance.

Water Supplies. — Inasmuch as the water supply of the cow barn is frequently employed for purposes of cleansing the utensils used in the production and sale of milk, it is of extra importance that this should be protected from pollution. Ordinary polluted water may cause no injury whatever in animals that drink it, but it may be productive of disastrous effects in man when used for the cleansing of cans, if the pollut-

ing material contain the germs of infectious human diseases; and experience has shown that not a few epidemics of typhoid fever have occurred in this State and elsewhere in consequence of the pollution of the water supply by the excreta of persons sick therewith or convalescent therefrom; and in a number of instances it has been proved that milk responsible for the dissemination of typhoid fever has been produced at farms where persons, either sick or convalescent, were employed about the cows. Letters were sent in reference to water supply as follows: advising the protection of the well from surface drainage, 37; condemning the use of well water on account of obvious contamination, 15; advising the protection of the milk trough in which the milk is cooled, 9; advising a change in the method of disposal of the kitchen drainage, 6; directing the closure of an open cess-pool, 2; and directing attention to the fact that pigs were wallowing in the water used not only for the watering of stock but for the cleansing of utensils, 1.

Care of Milking Pails and Other Milk Utensils. — It is generally recognized that dirty milking pails and other utensils beget sour milk, with consequent loss to the producer; therefore, in most cases these vessels are looked after with reasonable diligence. But it is not enough that they should be made clean: they should be kept in a suitable place, and under such conditions that they may not become invaded by dust, containing, as is always the case, bacteria of various kinds. The necessity of providing a milk room for the proper handling and storage of milk was brought to the attention of 637 owners. On some of the worst-kept farms the grossest carelessness was observed in the treatment of cans and other vessels. In 24 instances cans were observed scattered over the floor; in 6, scattered about the yard; in 2, lying about in the dirty cellar; in 3, standing in manure. At 11 places cans and other utensils, strainers, etc., were found standing in unwashed condition, in the middle of the day, apparently ready for use again. In one case the milking pail was found doing service in what passed for a laundry.

Other matters called to the attention of producers were as follows: the undesirability of keeping cows in the house cellar, 2; the washing of milk cans and pails in dirty water, 1; the cooling of milk (*a*) in dirty water, 2; (*b*) in a butter tub, 1; (*c*) in a wash tub, 1; (*d*) in a dirty tub, 3; (*e*) in a tub standing in the sun, 5; (*f*) in a manure cellar, 13; (*g*) in a house cellar, 2; (*h*) in a drinking trough, 12; the presence of a decomposing dead horse in the cow yard, 1; the presence of rotting ensilage in the tie-up, 2; the presence of decomposing cow entrails underneath the tie-up, 1; the necessity of raising barn to such a height from the ground that liquid manure would not spurt up between the boards of the floor under the weight of a person crossing the same, 3; the use of cotton waste as bedding, 8.

A DESCRIPTION

OF

THE NEW ANTITOXIN AND VACCINE LABORATORY,

TOGETHER WITH

A TEN YEARS' RETROSPECT OF THE PRODUCTION AND DISTRIBUTION OF DIPHTHERIA ANTITOXIN.

By THEOBALD SMITH, M.D., *Director of the Laboratory.*

The New Antitoxin and Vaccine Laboratory.

A Ten Years' Retrospect of the Production and Distribution of Diphtheria Antitoxin.

The discovery by Behring of the antitoxic power of the blood in animals treated with diphtheria toxin, and the successful attempts of Behring, Roux and others to produce antitoxin on a large scale, led Dr. H. P. Walcott, chairman of the State Board of Health, in 1894 to consider the advisability of establishing a laboratory for the production and free distribution, under State supervision, of this preventive and curative serum.

There might have been at that time, in the minds of some of those interested in the public welfare, reasonable doubts of the desirability of this new departure; but, viewed from the standpoint of to-day, this plan has proved to be eminently wise and the undertaking fully justified. We need simply to consider the price of antitoxin to-day to be convinced of the advantages of an economically managed State institution in supplying those quite unable to pay for the serum.

In the autumn of 1894 the preparation of antitoxic serum was begun tentatively by Dr. J. L. Goodale, in a laboratory of the State House. The horses were kept in a stable on the grounds of the Bussey Institution of Harvard University, near the Forest Hills station. Some serum was distributed as early as the spring of 1895. At that time the writer fitted up a number of laboratory rooms in the Bussey Institution, and took charge of the work as soon as the laboratories were ready, in the early summer.

For a period of nine years the preparation of diphtheria antitoxin was carried on in the Bussey Institution under the personal direction of the writer. This close supervision was made possible by the establishment of the chair of comparative pathology in the Harvard Medical School, through the munificence of Mr. George F. Fabyan. The laboratory connected with this department was practically coextensive with that of the serum laboratory, and permitted that co-operation which enabled the writer not only to direct the routine work, but also to engage in investigations directed towards the improvement of the serum and the greater accuracy of standardization.

With the increasing demand for serum, culminating during the epidemic of 1900–01, the quarters in the Bussey Institution became more and more inadequate; and it was evident that the time had come for the State to take cognizance of this eminently philanthropic work by providing more appropriate quarters, and placing the preparation of diphtheria antitoxin on a more stable basis.

At the same time another problem was brought forward, which involved the preparation and free distribution of vaccine lymph by the State Board of Health. The importance of some direct supervision and control of this prophylactic substance by the State had been felt for a long time; but any supervision of a product made largely outside of the State and by a number of different parties was impossible. The only solution was the assumption by the State itself of the preparation of the lymph, as is the practice in nearly all European countries.

The legislative proceedings leading up to the final act authorizing the production and distribution of antitoxin and vaccine lymph by the State Board of Health have been kindly abstracted and summarized for me by Dr. G. B. Magrath. I shall only indicate the chief steps.

In February, 1902, a bill was introduced into the Senate and the House that the State Board of Health be authorized to produce antitoxin and vaccine lymph. Near the end of the session, in June, a resolve was passed by both houses, providing for the investigating and reporting by the State Board of Agriculture on the feasibility and probable cost of producing vaccine lymph at the Massachusetts Agricultural College for free distribution in the Commonwealth. During the session of 1903 the General Court, after receiving the report of the State Board of Agriculture, and after much debate on the advisability of authorizing the manufacture of vaccine lymph, finally passed a bill during the closing days of the session of 1903, which authorizes the State Board of Health to produce and distribute antitoxin and vaccine lymph.

To obtain a suitable site for a State laboratory, free from objectionable surroundings, with sufficient land about it to secure light and air, and not subject to the complaints or the objections of fastidious neighbors or sensitive real estate owners, would have been impossible without acquiring a large and expensive tract.

To overcome this difficulty, the Corporation of Harvard University came to the aid of the State, and agreed to use a portion of the land of the Bussey Institution adjoining the Arnold Arboretum, and build a laboratory in which the preparation of diphtheria antitoxin and animal vaccine could be carried on together. After the passage of the bill authorizing the State Board of Health to prepare diphtheria antitoxin and vaccine, the writer visited again a number of vaccine institutes in Eng-

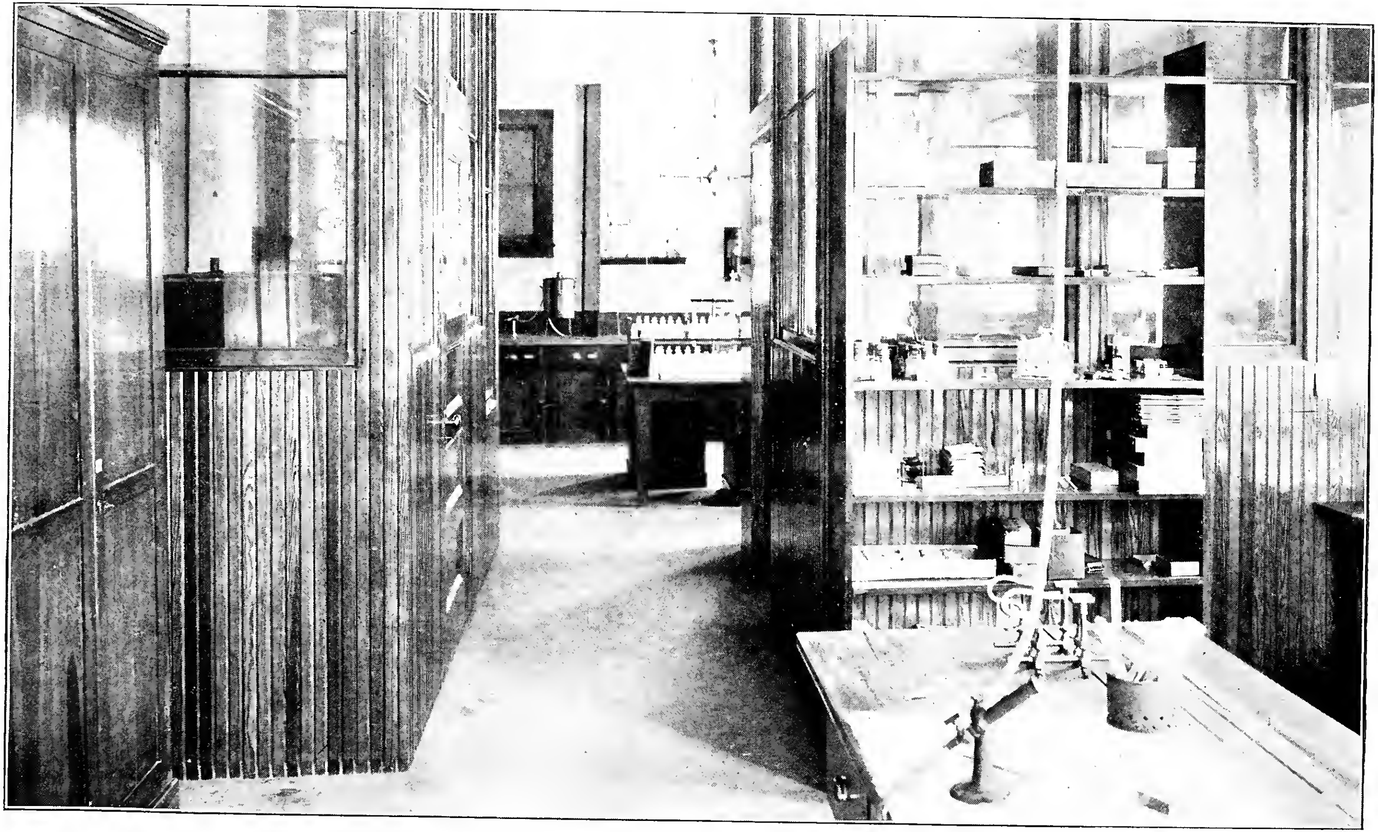

Fig. 4. THE GENERAL LABORATORY.

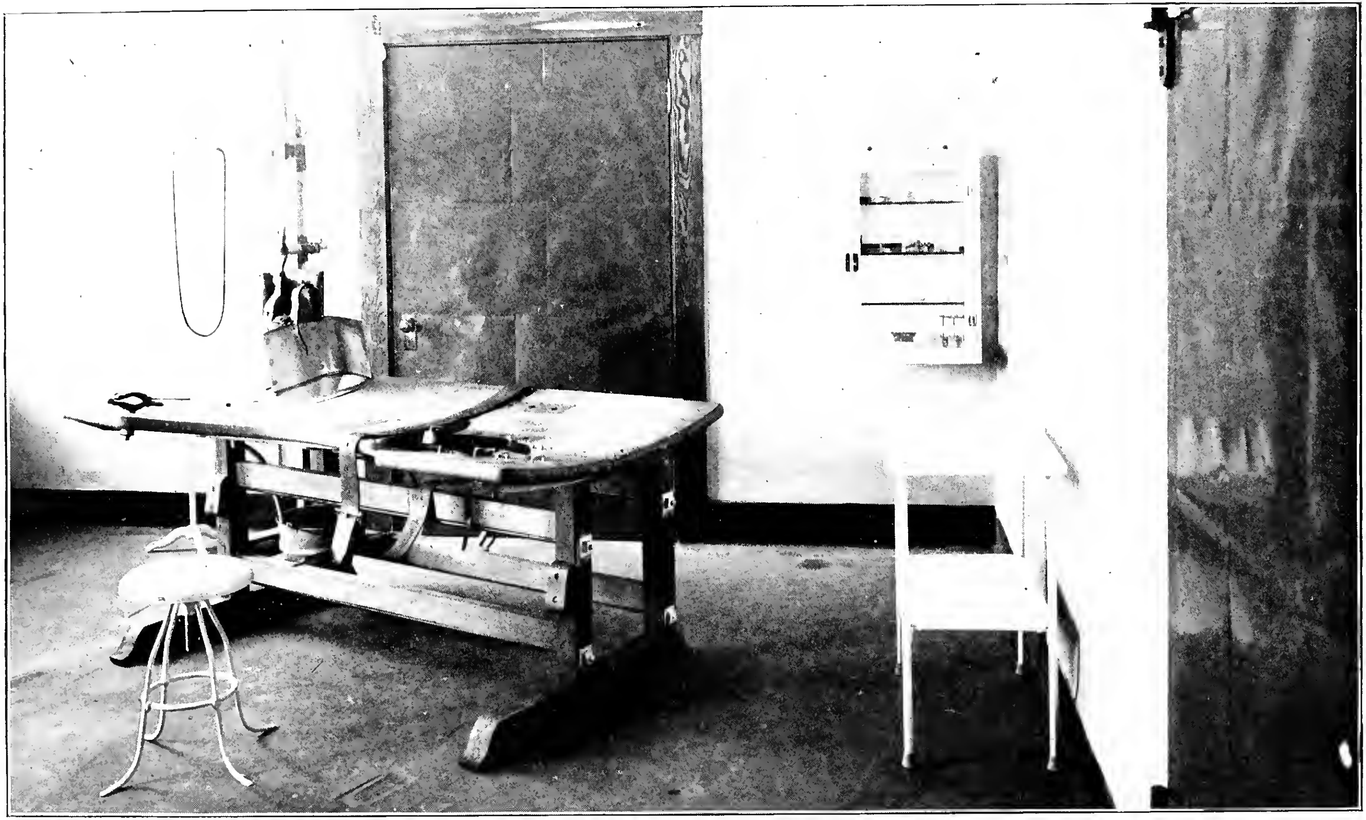

Fig. 3. THE OPERATING ROOM FOR CALVES.

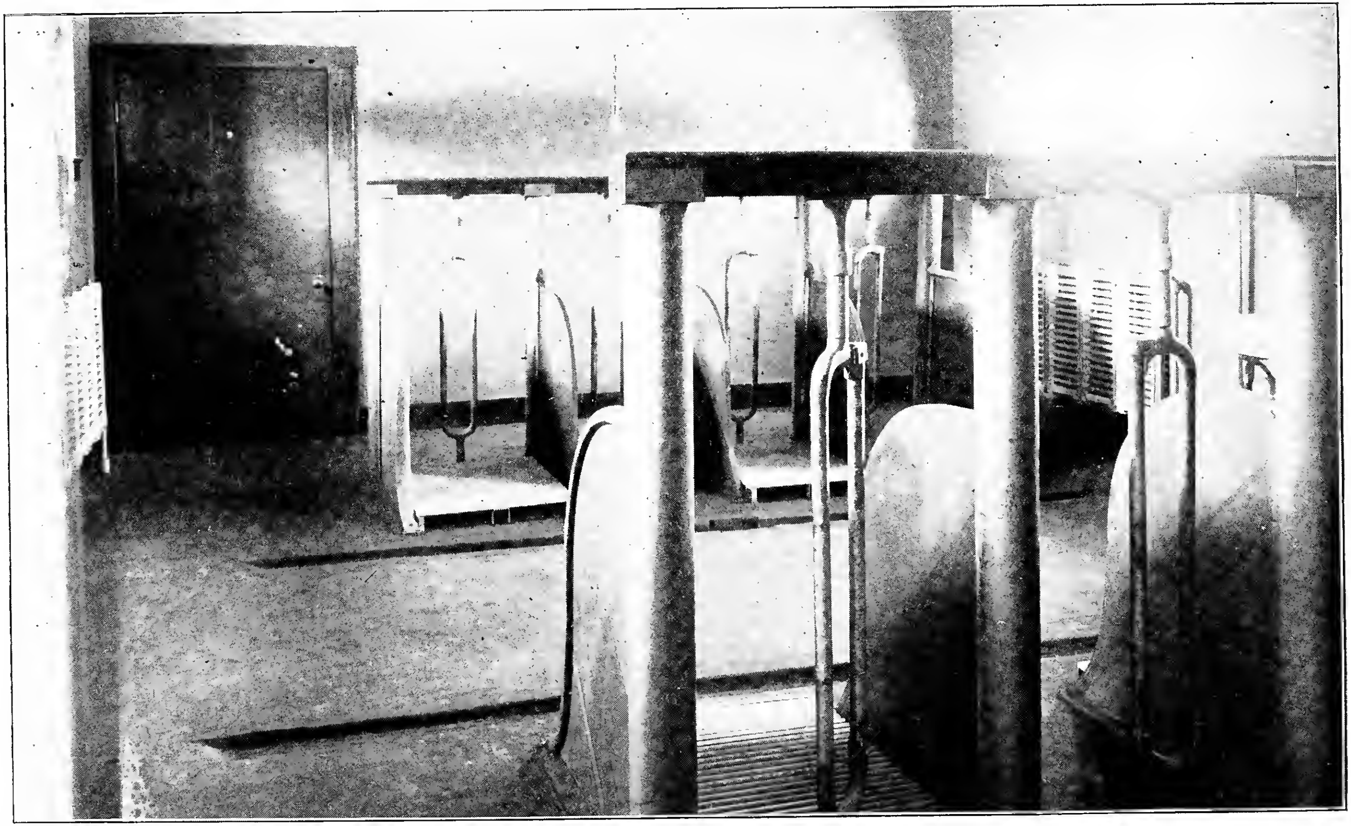

Fig. 2. THE STABLE FOR VACCINATED CALVES.

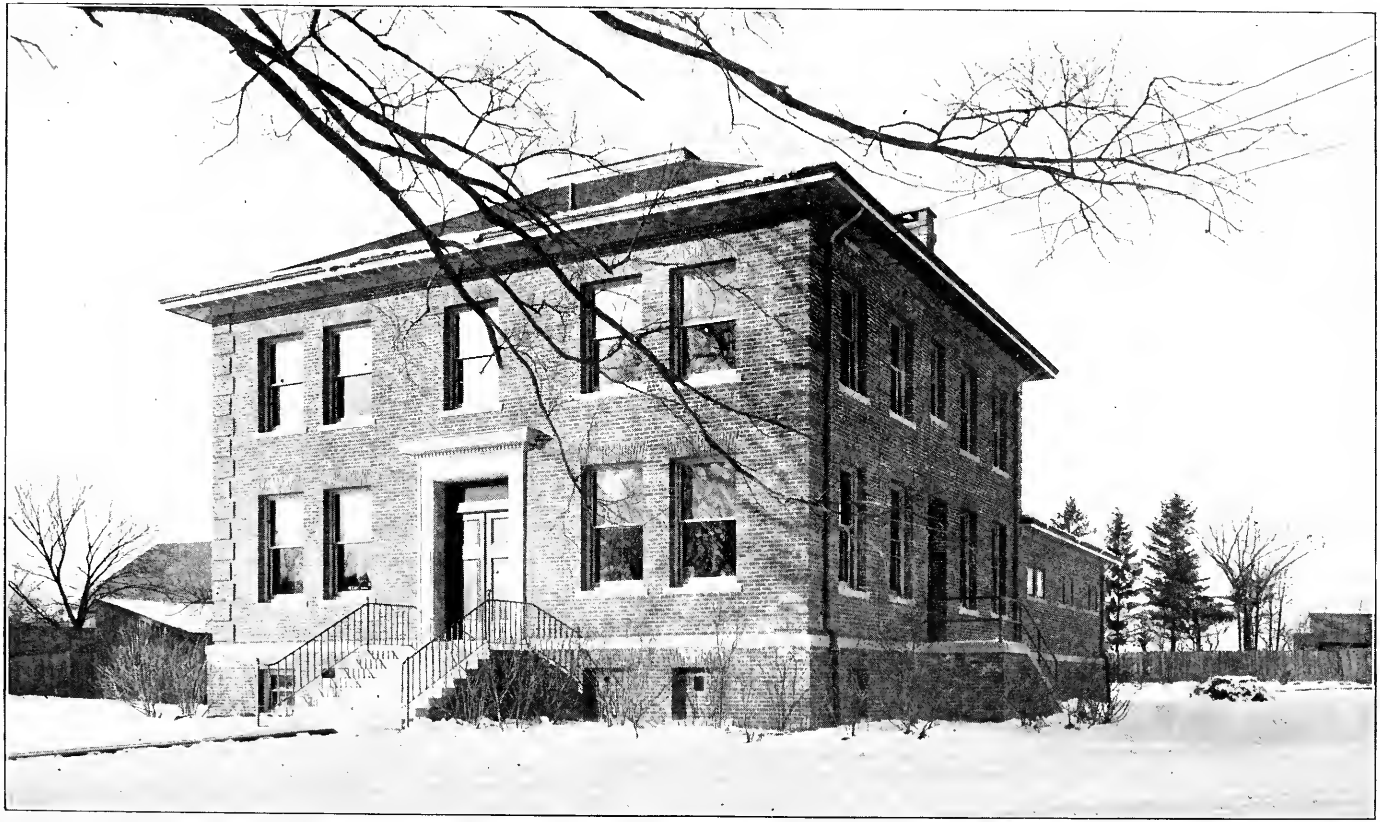

Fig. I. THE ANTITOXIN AND VACCINE LABORATORY.

land, Germany, France and Denmark during the summer of 1903. In the fall of the same year the site for the new building was selected, the plans made and the building begun. On account of the very severe winter of 1903 and 1904, building operations were almost wholly suspended until late in March. However, the work progressed uninterruptedly in the spring, and the building was ready for occupation in July. The production of antitoxin continued without interruption in the old laboratory during the installation of apparatus in the new. The production of vaccine was begun in July, and late in September the first lot was issued.

The building is situated on South Street, about one-quarter of a mile beyond the Forest Hills station of the New York, New Haven & Hartford Railroad. It faces slightly east of south, and receives an abundance of sunshine, as no shadows from other structures fall upon it. The windows have been constructed amply large to admit plenty of light. The situation is ideal, as the building stands in a park reservation of over 200 acres of land.

The general character of the building may be seen by an examination of the reproductions of photographs of the exterior and several interior rooms. The building is nearly square, and has an extension or wing consisting of basement and first floor only. This wing was designed to house the calves after vaccination. The floors are of cement in the basement, of cement covered with a layer of asphalt in the remainder of the building. The walls and ceiling are covered with a very hard plaster, and painted with enamel paint to give a smooth surface, easily washed and disinfected. The doors are covered with tin and heavily painted, and fit into iron frames. The structure is thus nearly fireproof. It is lighted by electricity.

In planning the arrangement and division of the interior for the production of diphtheria antitoxin and animal vaccine, our own experience in the preparation of antitoxin, covering a period of nine years and an extensive investigation of existing vaccine plants of this country and Europe, were used as a guide. The general arrangement of rooms may be seen in Figs. 6, 7 and 8.

In the basement (Fig. 6) room A is used as a receiving room, where apparatus, supplies, etc., are unpacked; room B serves as a place for guinea pigs, rabbits, mice, etc., used in the testing of antitoxin and vaccine; C is a vault with double brick walls, in which the serum and vaccine are stored; D is a store room which contains the hot-water plant for heating the building; and E is a general store room.

On the first floor (Fig. 7) room No. 1 is the director's room, and is also used for the storage of valuable apparatus. Room No. 2 is a docu-

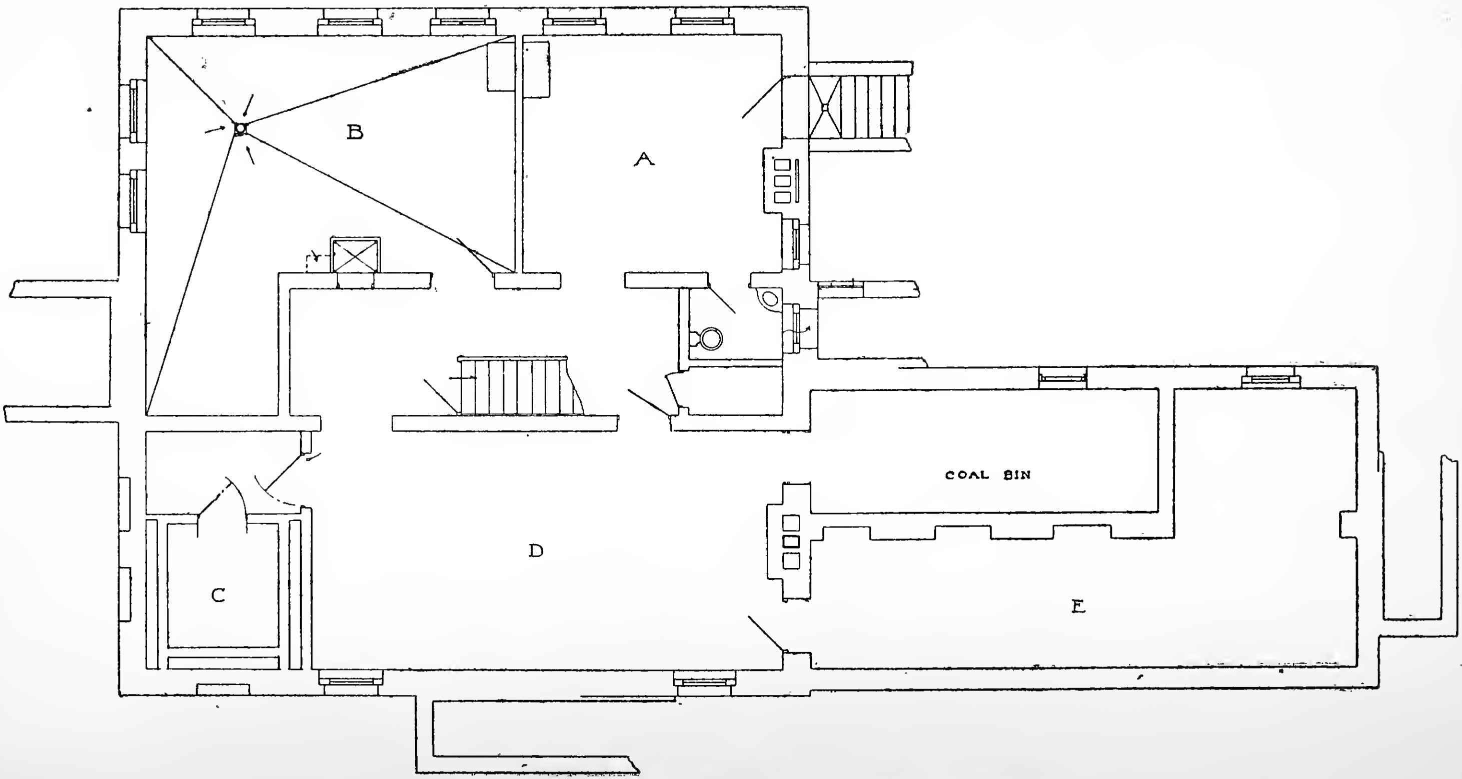

FIG. 6. ANTITOXIN AND VACCINE LABORATORY. PLAN OF BASEMENT.

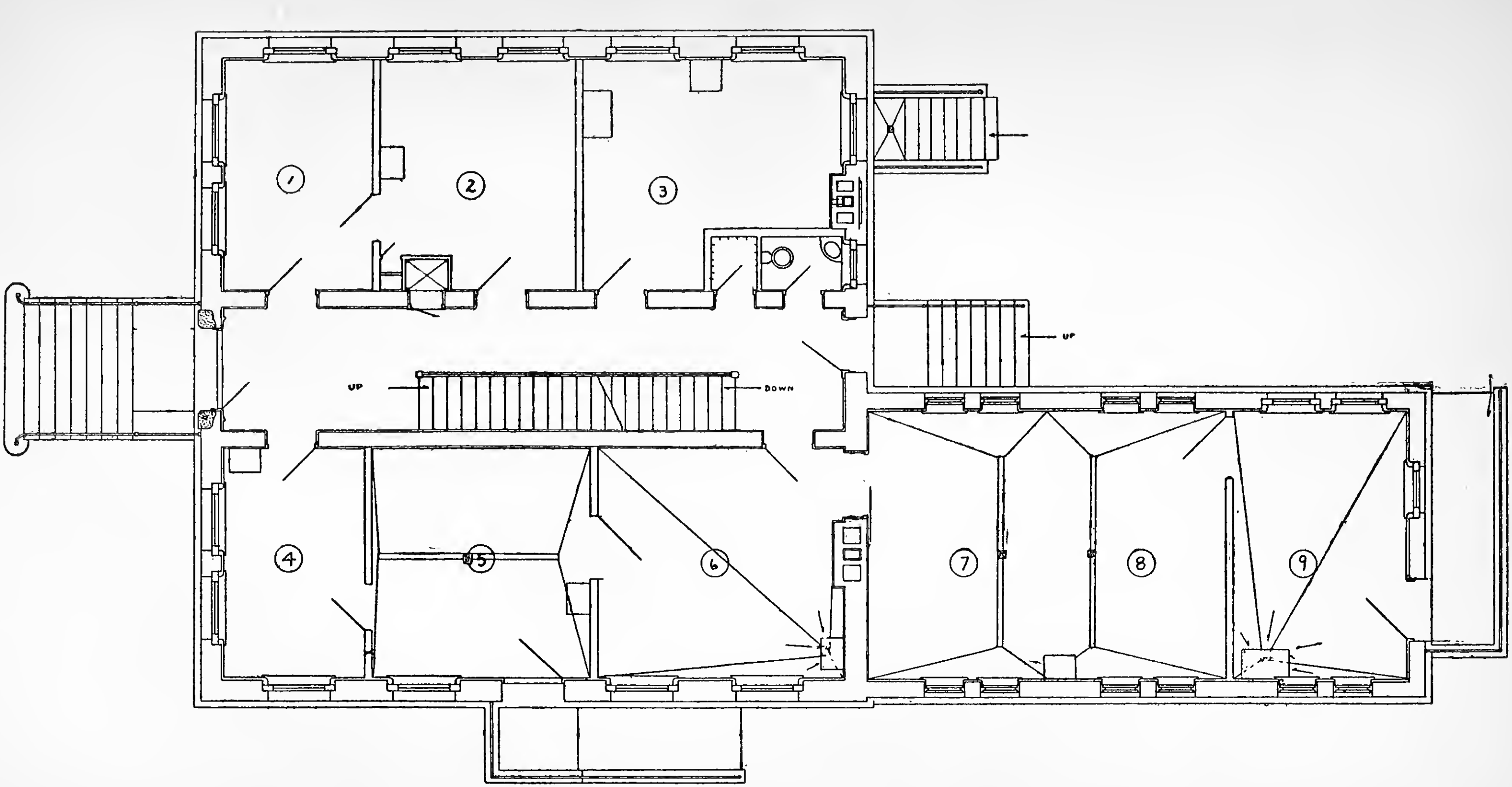

FIG. 7. ANTITOXIN AND VACCINE LABORATORY. PLAN OF FIRST FLOOR AND WING FOR CALF STABLE.

ment room, and provides desk room for assistants. In room No. 3 all the glass-ware used in the building is cleaned and sterilized. It contains also a large autoclave, in which culture media, milk, hay, etc., are sterilized. Room No. 4 is at present set aside for the testing of serum and vaccines, and for other operations on small animals. The remainder of this floor, including the wing, is set apart for cleaning, housing and operating on calves used for the production of vaccine. These animals are driven up an incline on the rear of the wing to room No. 9, where they are thoroughly washed and then placed in room No. 7–8, which is fitted up as an incubation stable; *i.e.*, the place where the animals are kept during the development of the vaccinal eruption (Fig. 2). This stable has windows facing northeast and southwest, and receives abundant sunshine. The floor is concrete, covered with asphalt. The fittings, as may be seen from the photograph, are almost entirely of slate and iron.[1] The walls of this stable are finished like those of the other parts of the building, and they can be easily washed and disinfected.

Room No. 6 is the operating room, and Fig. 3 gives a fair idea of its furnishings. Here the calves are fastened to the operating table, shaved and vaccinated and returned to the stable. After a certain number of days (four to six) the calves are returned to the table and the vaccinal eruption removed.

Room No. 5 is fitted up like the stable, to be used for calves in case of emergency. It has a special entrance. It is ordinarily used for sterilizing water and the instruments and gowns used during the operations on calves.

On the second floor (Fig. 8) room No. 10 is set aside for the filtering and bottling of diphtheria antitoxin. Room 12 is similarly reserved for the grinding of vaccine and for filling it into tubes. Between these two rooms is No. 11, in which all culture media are prepared.

On the other side of the hall is a large single room, devoted to bacteriological and other work incidental to the preparation of diphtheria toxin and the bacteriological testing of vaccine (Fig. 4). For this purpose a little room (No. 15) has been set aside as a place free from drafts and dust. Incubators are kept in the space marked 16. Lastly, in the small room No. 13 the vaccine is packed for distribution.

It will be seen that the building has been arranged quite exclusively for the routine preparation of the products authorized by law. Any extensive investigations are not to be undertaken here, as no space has been set aside for this purpose. For minor investigations, looking towards the steady improvement of the products, there are ample facili-

[1] For the plans of the stalls I am indebted to the vaccine laboratory of the New York City board of health, Dr. J. H. Huddeston in charge.

ties, however. In deciding for this plan, the writer had in mind the safeguarding of the products. By banishing bacteriological work not

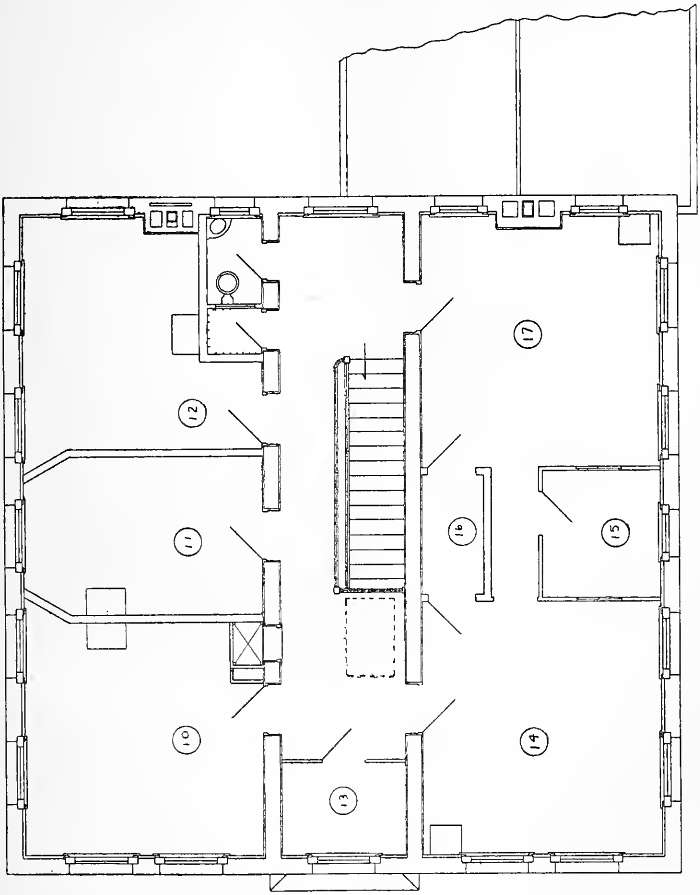

Fig. 8. Antitoxin and Vaccine Laboratory. Plan of second floor.

immediately bearing upon the problems of antitoxins and vaccines, the latter are not likely to become infected.

A Review of the First Decade of Antitoxin Production and Distribution by the State.

The progress in the production of diphtheria antitoxin during the past ten years has not been revolutionary, but satisfactory in many ways. It has been due in part to commercial competition, but chiefly to the scientific investigations of public laboratories which are not influenced by the stimulus of financial returns.

There has been a marked increase in the strength of antitoxic serum. That which was regarded as of quite satisfactory concentration in 1895 would be rejected at present. This improvement was due chiefly to advances in the methods of producing concentrated toxins, coupled with the discovery of races of bacilli which produce far more than the average amount of toxin in culture fluids. It was furthermore due to the elimination of horses which under any treatment produce but little antitoxin. By a careful selection of horses and the use of a concentrated toxin for immunization, sera of very great potency have been obtained. These are, however, exceptional since only a very small percentage of horses produce sera of high potency.

The problem confronting a public institution, the products of which are distributed without charge, is how far it is wise to go in the attempt to produce antitoxins of high potency. Thus far the policy of the writer — and in this he has had the support of the Board — has been to produce an abundant and safe supply of diphtheria antitoxin at a minimum cost to the State. The cost of producing antitoxin rises rapidly out of proportion to the increase in the strength of the serum. At the same time, there is no demonstrable difference in efficacy between an antitoxic unit which is contained in $\frac{1}{300}$ c. c. and one contained in $\frac{1}{400}$ c. c. In the former case it is necessary to inject one-third more serum than in the latter, in order to introduce into the body the same number of units. In using a 200-unit serum it would be necessary to inject twice as much as would be required of a 400-unit serum. At the same time, the cost of producing a 400-unit serum would be nearer three times than twice that of a 200-unit serum.

The reason for this is to be found in the fact that, while it is not difficult to obtain horses which under a conservative treatment with diphtheria toxin will yield a 200-unit serum, a relatively small per cent. of the horses as they ordinarily are obtainable yield a serum of 400 units per c. c. and above. The problem confronting the producer is one of trial and selection, since no reasonable treatment of a considerable number of horses will yield even a 200-unit serum.

In view of the fact that the serums having a strength of from 200 to 400 units are always producible, and can be stored during the summer and fall for use during the winter season without appreciable loss of strength, the writer has followed the plan of distributing sera of a medium strength only, leaving it free to those who desire the sera of higher potency to purchase them in the open market. This seems to be the wisest policy for a system of free distribution of a product which varies quantitatively rather than qualitatively in its protective and curative properties. It has amply justified itself in the brilliant results ob-

tained with a 200–250 unit serum at the south department of the Boston City Hospital, in the hands of Dr. J. H. McCollom. In the State at large the strength of the serum dispensed has fluctuated between 300 and 375 units per c. c.

Parallel with the increase in the strength of the serum produced, there has been a corresponding improvement in the method of testing this strength. The unit first established was found by Ehrlich to have no uniform basis, since the combining power of the different toxins obtained from different bacilli varied. He therefore established an arbitrary unit founded on the original unit, which was supposed to neutralize approximately 100 minimum fatal doses of the toxin towards guinea pigs weighing about 250 grams. This unit, which is carefully maintained in the Prussian Institute at Frankfurt a / Main, is sent to all those desiring it, every two months, for a small annual charge. Within the present year the Public Health and Marine Hospital Service at Washington has entered upon the preparation and maintenance of the antitoxic unit along the lines laid down by Ehrlich, and the unit is now obtainable from that source.

The establishment of such an accessible measure of antitoxic strength has greatly aided the various laboratories in dispensing sera of guaranteed potency.

With these improvements there has steadily risen the amount of antitoxin used in the treatment of diphtheria. While a dose of 1,000 units was recommended as sufficient ten years ago, the United States Pharmacopœia of 1900 recommends an initial dose of 3,000 units. The introduction of an animal product into the Pharmacopœia is in itself a signal triumph of the antitoxin, and an indication of the assured position which it has attained as a remedy in diphtheria.

Coupled with these various advances are others of a less obvious character. Among these are the various devices resorted to by private manufacturers to simplify and make easy the administration of the fluid. For this purpose nearly all private manufacturers have adopted the device of filling antitoxin directly into a syringe. This may be unpacked, and the fluid injected under the skin by simply putting the needle in place.

We have not entered into competition with these devices, for several reasons. In the first place, every physician must know how to use and keep clean hypodermic syringes. In the second place, such devices render the product more costly to the State.

For the production of diphtheria antitoxin the number of horses required has fluctuated from eight to fourteen, according to the season. As there are, up to the present, no characters known to the writer be-

tween a good and a poor antitoxin producer, the horses obtained by purchase are all subjected for two to three months to the usual process of immunization, which consists in the periodical injection under the skin of increasing doses of diphtheria toxin. If, after this preliminary treatment, a test of the serum falls below a certain level, the horse is rejected, and a new one put in his place. A considerable item of expense has been the great increase in the cost of horses, amounting at present to two or even three times the cost in 1895.

The total production of antitoxic serum since Jan. 1, 1897, when a new method of recording was introduced, to Dec. 31, 1905, is equivalent to 496 gallons. Of this, a few gallons only have been rejected because they did not come up to the expected level of strength. All the rest has been distributed over the State. Of this, very little has been returned, for the direct relation existing between the producing laboratory on the one hand and the local boards of health and the hospitals and physicians on the other makes it unnecessary for them to keep a large supply on hand.

A more accurate method of estimating production is not in amount of serum, but in units, for it is evident that 100 gallons of a 200-unit serum is equal to but 50 of a 400-unit serum. In the following table we give the annual distribution in terms of 1,000-unit doses: —

Diphtheria Antitoxin distributed from Jan. 1, 1897, to Jan 1, 1906.

Year.	Amount in 1,000-Unit Doses.	Year.	Amount in 1,000-Unit Doses.
1897,	4,455	1902,	50,400
1898,	9,263	1903,	57,622
1899,	33,997	1904,	75,185
1900,	81,073	1905,	73,877
1901,	67,972	Total,	453,844

The fluctuation in the demand during the different months of the year is quite marked. It is lowest in July and August, slightly higher in September, and very much higher in October, the beginning of colder weather and the school year. It remains high during November, December and January, and falls gradually from February to July. These figures may be greatly changed by the occurrence of epidemics, which may begin early in the fall, or last into June from the winter months. In the following table the distribution by months during the past nine years is given for each month: —

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1897, . .	290	271	251	285	300	202	641	208	175	501	693	638
1898, . .	319	204	250	991	666	407	602	557	519	1,091	1,923	1,734
1899, . .	1,147	1,430	1,831	1,319	1,404	1,712	2,058	1,674	3,179	5,898	5,818	6,527
1900, . .	8,338	5,620	6,321	4,636	6,956	5,718	4,643	5,884	6,192	8,060	9,721	8,984
1901, . .	8,793	6,200	6,650	6,000	5,600	4,650	3,625	4,000	3,201	6,711	6,000	6,542
1902, . .	5,800	4,600	3,200	5,200	3,800	3,200	3,200	2,800	3,200	5,200	5,800	4,400
1903, . .	5,800	4,400	3,800	3,800	4,000	3,800	3,200	2,736	3,800	7,520	7,400	7,366
1904, . .	7,800	6,100	5,200	4,512	6,356	5,932	5,345	4,800	7,400	7,500	7,500	7,740
1905, . .	6,348	6,720	5,784	7,553	7,452	5,716	2,000	3,412	3,740	7,580	8,472	9,100
Total, .	44,635	35,545	33,287	34,296	36,534	31,337	24,314	26,071	31,406	50,061	53,327	53,031

The distribution for the years 1895 and 1896 is not given, because in January, 1897, a new method of recording went into effect which has enabled the laboratory to keep an exact account, with but little labor. The tables show very strikingly the steadily growing use of antitoxin in Massachusetts. Up to 1899 the demand was insignificant, mainly because the city of Boston had a plant of its own up to that time. In 1900 and 1901 there was a great increase in the number of cases, and the total amount distributed was larger than in earlier or subsequent years.

The free distribution of antitoxin in Massachusetts has made itself felt in the use of much larger doses of serum than elsewhere, and it has probably tended to raise the dosage throughout the country. This influence has been salutary, for it has been shown that the doses used in the earlier years of antitoxin production were too low.

Tetanus Antitoxin.

During the years 1898–9 the laboratory prepared tetanus antitoxin, and distributed a considerable amount for use in cases contracted as a rule on Independence Day from toy pistols, etc. The results of its use were not specially encouraging. It was, therefore, considered best, in view of the small laboratory quarters and the danger of having tetanus cultures and tetanus toxin in close proximity to the diphtheria antitoxin, to give up the preparation of tetanus antitoxin. The writer does not wish to give the impression that tetanus antitoxin is useless. It is probably of great value when used preventively after injuries which may lead to tetanus, and without doubt it occasionally saves lives. It can now be obtained from a number of manufacturers, and is therefore not inaccessible.

The Production and Distribution of Vaccine Lymph.

The production of vaccine lymph on a large scale has become necessary in the struggle of a dense population against such a pervasive virus as that of small-pox. Isolation does not succeed in itself alone to suppress an outbreak. The need for individual protection conferred by vaccine lymph had been fully appreciated by the medical profession during the nineteenth century. Hence the law in this State that children cannot enter the public schools without this protection.

The success of the public sanitary organization in promptly isolating cases of infectious disease has led the public in recent years to regard the value of vaccination as a protection against small-pox with more indifference than our forefathers, who did not have boards of health and other sanitary organizations, ready at a moment's notice to seize the first case and isolate it in small-pox hospitals. Abetting this indifference is a widespread fear among the more intelligent of the laity of the dangers of vaccination. This fear is chiefly an heirloom of former generations, when human vaccine lymph was used almost exclusively, and when certain human infections were occasionally transmitted in the lymph.

The use of carefully prepared and previously tested animal vaccine to-day should not give rise to any difficulties, unless the operation be carelessly performed, or the wound not properly protected from subsequent infection. If the lymph is prepared without proper precautions, it may give rise to various local troubles, due to the presence of miscellaneous bacteria, in spite of the care exercised during and after vaccination.

It being the attitude of the State that individuals living within its borders should possess vaccinal immunity, and that this is best accomplished by vaccinating the young, the duty of the State in providing a safe and efficient vaccine lymph is self-evident. To exercise supervision over a number of vaccine plants in and out of the State being impossible, the only alternative is the assumption by the State itself of the responsibility of preparing and distributing vaccine. In European countries this duty is to-day generally recognized and assumed by public authority. In our own country scarcely a beginning has been made. Massachusetts is as yet the only State which has taken up this task. Other States will be certain to follow, for the production of animal vaccine by the State is a logical necessity. Furthermore, it is the only way to bring the physician who performs the vaccination in close touch with the producing laboratory. It eliminates the various middlemen, in whose hands the vaccine is likely to deteriorate.

The legislation which led to the establishment of a vaccine laboratory has already been referred to. It will be seen from the brief summary that it encountered considerable opposition. Strongly in its interest was the medical profession of the State. The physicians realized the need of being able to know where and how the vaccine was prepared, and those who were finally entrusted with its preparation fully appreciated the responsibility involved.

Vaccine differs essentially from diphtheria antitoxin; in fact, there are hardly any points of similarity, beyond the one that both are inoculated into human beings. This, however, is the focal point of the whole matter, and every step in the preparation must be regarded from the standpoint of its use upon human beings, and more particularly children. It is the use of various checks and safeguards which controls the entire process and probably doubles or triples the final cost. Vaccine differs from antitoxin in its perishable quality. Although certain strains of vaccine kept in the cold may still be very active after seven or eight months of storage, others may be inactive after three or four months. This is not the case with diphtheria antitoxin, which remains practically unchanged for six months, and thereafter loss of antitoxic power proceeds very slowly.

Again, antitoxin is prepared at the outset free from bacteria or other micro-organisms. This is not possible in the preparation of vaccine lymph. The development of the vaccinal eruption on the surface of the calf's body, the presence of exudations, the slight formation of crusts, favor certain ordinary bacteria of the skin, and the fresh lymph always contains bacteria. These, however, coming from the calf, have been shown by many investigators to be harmless to man. They are probably far less harmful, and are present even in fresh lymph in much smaller numbers, than those in the milk we drink on a summer's day. No one would be very much exercised over the operation of slightly scratching the skin and placing on the scratch a drop of milk; and yet this operation would be far more serious, from a bacteriological standpoint, than the introduction of vaccine lymph, so far as the bacterial content is concerned. This illustration serves to point out our indifference to daily occurrences, and our apprehensions towards those that occur but once or twice in our lives.

In the preparation of diphtheria antitoxin the laboratory equipment is more detailed than in the preparation of vaccine. It presupposes much more technical training, and cannot be undertaken except by well-trained medical bacteriologists. With vaccine the conditions are somewhat different. Any one who has witnessed the production of vaccine may pre-

pare it in an old cow stable, and some room where it can be put up for distribution. No technical knowledge is required, beyond ability to recognize the character of the eruption. Yet the preparation of such vaccine would be bare of all safeguards devised by modern medical science. It is the fundamental simplicity of the process which has induced many in the past to try their hand at making vaccine lymph.

To-day its preparation demands, among other things, the inspection by immediate autopsy of the health of the calves used for vaccine; the absolutely clean, aseptic condition of the incubation stable, and the sterilization of the feed of the animals used; general surgical asepsis in the operation of inoculating the animal and in removing the vaccine; the aseptic handling and sealing of the lymph; the removal of the bulk of the bacteria in lymph either by storage at low temperature for six to eight weeks, by carbolic acid, or chloroform; and finally the testing of the vaccine on small animals and at intervals by bacteriological methods. These are all precautionary processes, based on modern medical bacteriology, which have nothing to do with the essential production of vaccine. They simply hedge in by safeguards the process itself. The use of these safeguards makes it impossible for any but trained bacteriologists to direct the process, and demands laboratories and stables of special construction.

The Preparation of Vaccine Lymph.

It is of considerable interest to note that vaccine dispensed by different institutes is not derived from one and the same stock. There are three sources available: —

1. The virus descended from spontaneous cow-pox, and continued through an indefinite series of animals, — the true animal vaccine.

2. Virus obtained from animals which have been inoculated with lymph from human vaccine pustules, either directly, or indirectly through a series of calves. This is known as retro-vaccine.

3. Vaccine obtained by passing small-pox virus through the cow, — the so-called variola-vaccine. During repeated passages through the cow, the small-pox virus is profoundly altered, and converted into the relatively harmless vaccine virus.

It would probably be impossible for many vaccine plants to trace the genealogy of their current stock back to its beginnings. In Germany the use of lymph from the arms of children (retro-vaccine) has been a favorite mode of rejuvenating impaired animal virus.

An inspection of a considerable number of vaccine laboratories in Europe and some in our own country revealed the fact that each institu-

tion followed to a certain extent methods of its own. The general underlying principles were the same, for in all cases the end product was glycerinated pulp, *i.e.,* the vaccinal eruption removed with a curette and ground up into a fine suspension with diluted glycerine. The procedures for obtaining this end product differed in almost every possible detail. Animals of all ages were used, each institution confining itself to the use of those of a certain age. The method of feeding differed from place to place. The period elapsing between inoculation and the removal of the virus also varies considerably in different institutions. Some remove the vaccine at the end of three, others at the end of six, days; others choose a period of four or five days.

The essentials of the process are briefly as follows: —

Calves are chiefly employed. The preferred areas for inoculation are the abdomen, the inner aspect of the thighs, the scrotum, or simply one side of the animal. The thoroughly inspected, cleansed animal is fastened upon a suitable table, and the areas to be inoculated are shaved and washed. Disinfection of the skin with alcohol, lysol and other well-known disinfectants is variously practised and omitted by different authorities. In any case certain disinfectants must be removed with sterile water before the vaccine is applied. On this prepared area shallow incisions, barely deep enough to become reddened, are made in parallel lines from one-quarter to one-half inch apart. The vaccine or seed is thoroughly rubbed into the scarified area, and the calf released. Much time and ingenuity has been sacrificed by German vaccine producers in the effort to obtain a proper aseptic protective dressing for the vaccinated area, but nothing has been brought forward which has received general approval, and I think that to-day most vaccine producers use no dressing, but depend on general cleanliness.

After four to six days, according to temperature and individual variation, the calf is again placed upon the table. The vaccinated surface is thoroughly washed with sterile water, and any scabs or crusts removed. A curette is then used to scrape away the slightly elevated ridges of epidermis and subjacent layers, which represent the confluent eruption following the linear inoculation. This scraped material, or pulp, is thoroughly ground and comminuted in a mortar, or more frequently in a special machine, while being mixed with a definite amount of 50 to 66 per cent. of glycerine. When the process of grinding and mixing with glycerine has been completed, the vaccine is, as a rule, stored for at least a month before it is sent out. In emergencies, as in the sudden appearance of small-pox in large communities, vaccine may be distributed soon after removal from the calf, by subjecting it to some disinfecting process

which destroys nearly all the bacteria, but which leaves the vaccine virus intact. The most satisfactory agents are carbolic acid, introduced by the Japanese, and chloroform, first recommended by the English local Government Board (Dr. Greene).

The method of putting up the lymph for final distribution depends somewhat upon the manner in which it is to be used. If it is to be placed in the hands of public vaccinators, as is the case in Germany, the lymph is put into small glass vials holding from 10 to 100 doses each. If it is to be distributed in smaller lots, or even single doses, the method of sealing the lymph in glass capillary tubes is almost universal on the continent and in England. In our own country much diversity still exists. Being still largely in the hands of private parties, and prepared with commercial ends in view, the lymph has been put up in a manner designed more to simplify the operation of human vaccination for the physician than to safeguard the lymph. Moreover, the methods employed, other than that of the capillary tube, tend to increase the cost of the final product. These methods have been chiefly the result of competition among vaccine producers, just as the method of putting antitoxin into syringes ready for injection is the result of such commercial rivalry. A careful study of the various methods in use both in this country and in Europe led to the adoption of the simplest and perhaps the oldest and most universal method, — storage in capillary tubes, and, when large numbers are to be vaccinated, in small vials holding 25 to 50 doses each. The capillary tube with both ends sealed in the flame is sent out with a small bulb to be used for ejecting the lymph upon the scarified area. The following printed directions, issued with each lot of vaccine, describe the method of using the bulb: —

MASSACHUSETTS STATE BOARD OF HEALTH, VACCINE LABORATORY.

Directions for Using the Glycerinated Vaccine.

Vaccine should be stored in a cool place, protected from the light, preferably in a refrigerator.

Inasmuch as vaccine deteriorates in efficiency with time, it should be used promptly after distribution, and in no case later than the date stamped upon the package. The number on the glass container identifies the source of the vaccine. Tubes bearing the same number contain vaccine from the same calf. If, after a fair trial any lot should be found to yield poor results in primary vaccination the State Board of Health should be notified, and no more vaccine of that number should be used.

The operation of vaccination and the care of the vaccination area should be governed by the general principles of aseptic surgery.

There are various ways of inserting vaccine, and many kinds of vaccinating

lancets are in use. Perhaps the simplest procedure is to use a common sewing-needle previously sterilized in the flame. Scarify with it an area not to exceed 3 mms. ($\frac{1}{8}$ inch) in diameter. Two or three scarifications are commonly made. Draw as little blood as possible.

To remove the vaccine from the capillary tube, push the tube completely through the rubber bulb, as shown in Fig. 1. The tube is most easily inserted at the constricted end of the bulb. Now, break off or crush both ends with forceps or wire pliers and draw one end of the tube back into the bulb as shown in Fig. 2. To force out the drop of lymph, seize the bulb between the first and the second finger and compress the bulb with the thumb. When a small rubber tube accompanies the outfit, slip this over one end of the tube after the ends are broken off. By compressing the rubber tube, the vaccine is slowly forced out.

See that the instrument used in breaking off or crushing the ends of the capillary tube is free from infection.

The vaccinated area should be kept bared for a short time to prevent the wiping away of the lymph before absorption has taken place.

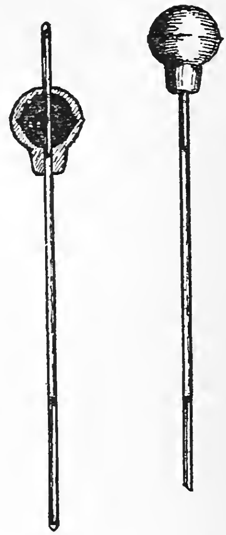

FIG. 1. FIG. 2.

If any protective covering is used, it should be so applied as to cause the least pressure and friction. In all cases the vaccinated area should be inspected at the end of a week.

The foregoing directions are intended merely as suggestions, to be modified and improved upon by the physician as his experience may dictate.

The capillary tubes are sent out in lots of 3, 5, 10 or more, put up in glass, wooden and paper containers, in the order named. The latter may be sealed, and the whole sent as first-class mail matter. Physicians requiring vaccine lymph may, by addressing the State Board of Health, State House, Boston, obtain by return mail the number of tubes desired. Many of the older physicians had been accustomed to the use of the "dry" points, which have now been almost wholly displaced. In order to accommodate these, and to change the method of vaccinating as little as possible, private manufacturers have endeavored to put up the glycerine-vaccine in imitation of the old "dry-point" method, by supplying these points in the vaccine container. This method is open to at least two objections. The lymph has to be manipulated more than is necessary, and the point is too coarse an instrument for vaccination. If the lymph is at all vigorous, quite large pustules result unless very great care is taken in scarifying. Some of the methods do not appear to protect sufficiently the lymph from possible exposure to contamination, and they allow so much air in contact with the lymph that rapid attenuation

or decline in efficiency might be anticipated and assumed unless definitely disproved.

These objections, to which must be added increased cost, led us to adopt the simplest method. Naturally enough, there has been some criticism of this method. The objections to it are due to a slight variation in the size of the capillary tubes, and consequently some difficulty in adjusting the rubber bulbs air-tight over them. The other objection would be due to careless work in filling them. If the lymph should become coagulated at one or both ends through the heat required in sealing in the flame, a solid plug would be formed, which could not be dislodged. This difficulty is easily avoided, with a little care. The bulb likewise is as a rule successfully manipulated, if the directions given in the circular are exactly followed.

The Distribution of Vaccine Lymph during the Year ended Sept. 30, 1905.

In the following table the amount of vaccine lymph dispensed from Oct. 1, 1904, to Sept. 30, 1905, is given, on the basis of individual doses, of which there are about 50 in 1 c. c. of the glycerinized lymph.

Date.	Number of Doses distributed.	Date.	Number of Doses distributed.
1904.		April,	2,453
October,	815	May,	4,310
November,	963	June,	1,173
December,	720	July,	1,220
		August,	4,508
1905.		September,	6,940
January,	1,243		
February,	1,104	Total,	27,909
March,	2,460		

Of this amount, 1,732 doses were returned unused, leaving 26,177 doses.

It will be seen that the largest amount of vaccine is used late in August and early in September, before the beginning of the new school year. The next highest demand comes in spring, perhaps the most favorable time for vaccination. It is somewhat unfortunate that nearly one-half of the vaccine lymph used during the year should be called for at the end of summer, since, from the standpoint of the laboratory producing it, it throws the preparation into the warm months of the year. It would be far better if the vaccine were used during April, May and June, thereby enabling the laboratory to prepare it in the winter months, when the conditions are most favorable.

REPORT

UPON THE

Production, Distribution and Use of Diphtheria Antitoxin and Vaccine,

AND UPON BACTERIOLOGICAL DIAGNOSIS,

FOR THE

Year ended Sept. 30, 1905.

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN

FOR THE

YEAR ENDED SEPT. 30, 1905.

The production of diphtheria antitoxin has continued under the direction of Dr. Theobald Smith, at the Bussey Institute. The distribution has been conducted, as before, at the office of the Board.

The total number of packages issued by the Board during the ten years and six months ended Sept. 30, 1905, was as follows: —

In 1895–1896 (year ended March 31), ...	1,724 bottles.
In 1896–1897 (year ended March 31), ...	3,219 bottles.
In 1897–1898 (year ended March 31), ...	4,668 bottles.
In 1898–1899 (year ended March 31), ...	12,491 bottles.
In 1899–1900 (year ended March 31), ...	31,997 bottles.[1]
In 1900–1901 (year ended March 31), ...	53,389 bottles.[1]
In 1901–1902 (year ended March 31), ...	40,211 bottles.[1]
In 1902–1903 (year ended March 31), ...	33,475 bottles.[1]
In 1903–1904 (year ended March 31), ...	41,133 bottles.[1]
During 6 months ended Sept. 30, 1904, ...	22,255 bottles.[1]
During 12 months ended Sept. 30, 1905, ...	47,387 bottles.[1]
	291,949 bottles.

The serum was distributed to local boards of health, to hospitals, and to practitioners in 183 cities and towns, 45 of which used more than 100 bottles each. The following table shows the distribution: —

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[1] These numbers have reference to the actual number of bottles issued in packages of about 1,500 units each. In order to make this comparable with the figures of the first three years (1895–98), a package of 1,000 units should be employed as a standard, so that the 269,847 bottles distributed since that time would be equivalent to about 405,000 of the strength at first employed.

Number of Bottles of Diphtheria Antitoxin distributed from Oct. 1, 1904, to Sept. 30, 1905.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Abington,	37	Chelsea,	300
Acton,	18	Cheshire,	104
Adams,	168	Chesterfield,	4
Agawam,	24	Chicopee,	60
Amesbury,	46	Clinton,	133
Andover,	66	Cohasset,	60
Arlington,	84	Colrain,	8
Ashland,	6	Concord,	54
Athol,	6	Cottage City,	6
Attleborough,	30	Cummington,	3
Avon,	13	Danvers,	295
Ayer,	18	Insane Hospital,	133
Barre,	26	Dedham,	46
Becket,	6	Dennis,	7
Bedford,	56	Dighton,	48
Belmont,	26	Douglas,	6
Beverly,	174	Dudley,	12
Billerica,	150	Duxbury,	6
Blackstone,	24	East Bridgewater,	36
Boston: —		East Longmeadow,	54
Children's Hospital,	2,237	Easthampton,	20
City Hospital,	13,272	Easton,	18
General supply,	5,850	Everett,	116
Massachusetts Charitable Eye and Ear Infirmary.	24	Fall River,	700
Massachusetts General Hospital,	1,008	Falmouth,	39
Massachusetts Homœopathic Hospital.	50	Fitchburg,	100
Saint Mary's Hospital,	125	Foxborough,	12
Training ship "Enterprise,"	2	Framingham,	24
West End Nursery,	120	Franklin,	24
Braintree,	20	Gardner,	6
Bridgewater,	6	Georgetown,	18
Brockton,	161	Gloucester,	374
Brookline,	425	Goshen,	3
Cambridge,	1,412	Greenfield,	12
Hospital,	100	Groton,	6
Canton,	30	Hanover,	12

Number of Bottles of Diphtheria Antitoxin distributed from Oct. 1, 1904, to Sept. 30, 1905 — Continued.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Hanson,	14	Milton,	48
Harwich,	12	Monson,	12
Hatfield,	18	Nantucket,	3
Haverhill,	196	Natick,	42
Hingham,	66	Needham,	43
Holbrook,	18	New Bedford,	1,302
Holden,	6	Newburyport,	72
Holliston,	16	Newton,	525
Holyoke,	522	North Adams,	544
Hopedale,	12	North Andover,	12
Hopkinton,	12	North Attleborough,	27
Hudson,	24	North Brookfield,	8
Hull,	18	North Reading,	6
Hyde Park,	287	Northampton,	30
Lawrence,	1,050	Northbridge,	24
Lenox,	12	Northfield,	14
Leominster,	79	Norton,	2
Lexington,	132	Norwell,	6
Lincoln,	4	Norwood,	123
Lowell,	1,927	Oakham,	8
Ludlow,	18	Orange,	14
Lynn,	800	Palmer,	42
Malden,	325	Peabody,	157
Mansfield,	36	Pittsfield,	185
Marblehead,	78	Plymouth,	42
Marlborough,	74	Princeton,	12
Marshfield,	6	Provincetown,	28
Maynard,	9	Quincy,	613
Medfield,	18	Randolph,	8
Medford,	144	Reading,	80
Medway,	37	Revere,	112
Melrose,	109	Rockland,	12
Merrimac,	4	Rockport,	24
Methuen,	66	Royalston,	3
Middleborough,	12	Rutland,	4
Milford,	72	Salem,	1,737

Number of Bottles of Diphtheria Antitoxin distributed from Oct. 1, 1904, to Sept. 30, 1905 — Concluded.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Salisbury,	4	Wareham,	6
Sandisfield,	6	Warren,	12
Saugus,	246	Watertown,	373
Scituate,	18	Waverly, School for Feeble-minded,	6
Seekonk,	6	Wayland,	6
Shelburne,	8	Webster,	18
Sherborn,	3	Wellesley,	30
Shirley,	5	West Bridgewater,	6
Somerville,	1,449	West Brookfield,	8
Southbridge,	612	West Springfield,	99
Southwick,	6	Westfield,	18
Spencer,	53	Westford,	3
Springfield,	900	Westport,	14
Stockbridge,	12	Weymouth,	196
Stoneham,	30	Whitman,	18
Stoughton,	6	Wilbraham,	42
Sutton,	4	Williamsburg,	4
Swampscott,	18	Williamstown,	26
Swansea,	12	Wilmington,	12
Taunton,	241	Winchester,	85
Tewksbury, State Hospital,	6	Winthrop,	66
Topsfield,	6	Woburn,	165
Wakefield,	72	Worcester,	975
Walpole,	4	Insane Hospital,	110
Waltham,	411	Yarmouth,	10
Ware,	105	Total,	47,387

The vaccine virus was distributed as shown in the following table: —

Number of Tubes of Vaccine distributed from Oct. 1, 1904, to Sept. 30, 1905.

City or Town.	Number of Tubes.	City or Town.	Number of Tubes.
Abington,	89	Boston:—	
Amesbury,	35	City Hospital,	465
Arlington,	109	General supply,	6,503
Attleborough,	83	Massachusetts General Hospital,	105

Number of Tubes of Vaccine distributed from Oct. 1, 1904, to Sept. 30, 1905 — Continued.

City or Town.	Number of Tubes.	City or Town.	Number of Tubes.
Boston — *Concluded.*		Marblehead,	15
Mt. Sinai Hospital,	75	Marshfield,	13
Penal institutions,	4,020	Maynard,	10
St. Elizabeth's Hospital,	106	Medfield,	10
West End Nursery,	189	Medford,	30
Braintree,	111	Medway,	30
Bridgewater,	9	Melrose,	116
Brockton,	175	Methuen,	134
Brookline,	413	Newton,	403
Cambridge,	618	North Adams,	150
Chelsea,	87	North Attleborough,	34
Clinton,	155	Norwood,	117
Cohasset,	75	Orange,	6
Colrain,	20	Palmer,	66
Cummington,	10	Hospital for Epileptics,	120
Dedham,	391	Pittsfield,	12
Duxbury,	24	Plymouth,	30
East Bridgewater,	8	Provincetown,	15
Everett,	232	Quincy,	634
Fall River,	1,840	Randolph,	12
Fitchburg,	585	Salisbury,	10
Foxborough,	58	Sharon,	6
Georgetown,	20	Sherborn,	10
Gloucester,	10	Somerville,	195
Hanson,	3	Springfield,	200
Haverhill,	10	Taunton,	386
Hingham,	100	Townsend,	10
Holbrook,	27	Wakefield,	187
Holden,	15	Walpole,	10
Hull,	50	Waltham,	183
Hyde Park,	8	Warren,	65
Kingston,	9	Watertown,	13
Lawrence,	838	Waverly, McLean Hospital,	50
Lexington,	66	Wellesley,	116
Lowell,	50	West Brookfield,	130
Lynn,	10	Westborough Insane Hospital,	120
Malden,	6	Westfield,	69

Number of Tubes of Vaccine distributed from Oct. 1, 1904, to Sept. 30, 1905 — Concluded.

City or Town.	Number of Tubes.	City or Town.	Number of Tubes.
Westminster,	10	Woburn,	23
Westport,	44	Worcester,	2,160
Weymouth,	204	Total,	23,970

Summary Observations upon the Use of Diphtheria Antitoxin in Massachusetts during the Year ended Sept. 30, 1905.

The whole number of returns of cases treated with diphtheria antitoxin furnished by the State Board of Health during the year ended Sept. 30, 1905, to hospitals and to local boards of health for use in general practice, was 2,132. Of this number, 1,615 were returns of cases of diphtheria treated with antitoxin, and 517 were returns of other persons who had been exposed to infection and were treated for the purpose of immunization. These cases constitute only a fraction of those which were treated during the year in the State with antitoxin furnished by the Board, since very many physicians failed to make returns to the Board.

Cases in which a Bacterial Examination was made.

The same methods of classification are continued in this report as were adopted in the reports of the previous nine years and six months. The cases in which cultures were made are classified into positive and negative cases. Diagnostic examinations were made in 1,339 cases reported to the Board as having been treated with antitoxin, and of these, 1,263 proved to be genuine cases of diphtheria and 76 gave a negative result.

Positive Cases.

Of the 1,263 positive cases, or those in which a diagnosis of diphtheria was made by bacterial cultures from the throat of the patient, there were 1,123 recoveries and 129 deaths, or 10.2 per cent.; the results of the previous years having been, respectively, 13.7, 11.6, 8.2, 7.9, 11.4, 9.4, 10.1, 9.8, 8.1 and 6.8 per cent. In 11 cases, whether recovery or death occurred was not stated.

Sex. — The number of males was 596, and the deaths of these were 62, or 10.4 per cent. The number of females was 663, and the deaths of these were 67, or 10.1 per cent. In 4 cases the sex was not stated.

Ages. — The following table shows the cases and deaths by ages: —

Year ended Sept. 30, 1905.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.). 1905.	Fatality (Per Cent.). 1904.
From 0 to 2 years,	117	36	30.8	15.8
From 2 to 5 years,	323	48	14.9	10.3
From 5 to 10 years,	400	32	8.0	5.7
Over 10 years,	409	11	2.7	2.4
Age unknown,	14	2	14.3	-
	1,263	129	10.2	6.8

Day of Illness when Antitoxin was first administered. — The following table presents the fatality, according to the day of illness on which the antitoxin was first administered: —

Day.	Cases.	Deaths.	Fatality (Per Cent.). 1905.	1904.[1]	1903.	1902.	1901.	1900.	1899.	1898.	1897.	1896.	1895.
First,	90	7	7.8	2.7	3.3	9.8	9.5	6.4	9.8	8.2	8.0	0.0	0.0
Second,	342	18	5.3	2.3	4.0	6.7	6.7	6.0	5.6	1.8	8.9	9.5	9.7
Third,	268	28	10.4	8.5	6.2	5.5	9.4	7.7	12.8	6.2	7.0	8.3	8.7
Fourth,	185	20	10.8	8.1	12.1	12.7	12.5	11.3	14.1	13.2	3.0	22.7	15.4
Fifth,	96	12	12.4	7.4	17.7	19.0	17.0	14.8	15.6	11.8	11.8	0.0	22.2
Sixth,	39	7	17.9	4.0	10.0	18.0	16.0	21.1	17.9	20.0	0.0	14.3	20.0
Seventh,	30	7	23.3	28.6	13.0	15.4	18.4	13.7	27.1	9.5	30.0	25.0	33.3[2]
Eighth and later,	64	10	15.6	8.3	8.5	17.8	18.5	16.8	14.7	10.4	13.6	16.6	-
Unknown,	149	20	-	-	-	-	-	-	-	-	-	-	-

[1] Six months only. [2] Seventh day and later.

The value of the foregoing table consists mainly in the definite statement of the fatality of cases according to the day of illness at which antitoxin treatment was begun. In general, it shows that the ratio of success in treatment depends largely upon the early date at which antitoxin is first administered. A fuller and more conclusive summary, embracing the whole period of ten years and six months, and containing greater numbers, may be found on a later page.

Of the number of positive cases reported to the Board, in which antitoxin was administered, those in which the treatment was begun either upon the first, second or third days of illness constituted 55.4 per cent.

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals,	994	112	11.3
In private practice,	269	17	6.3

Seasons of the Year. — The cases embraced in the foregoing enumeration occurred in the following order: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
1904.			**1905.**		
October,	177	13	April,	93	12
November,	164	20	May,	81	3
December,	137	13	June,	99	11
1905.					
January,	161	25	July,	79	4
February,	93	14	August,	61	5
March,	97	7	September,	20	2
Total six months,	829	92	Total six months,	433	37

By the foregoing table it appears that there were 433 positive cases reported in the warmer months, with 37 deaths; and 829 cases in the colder months, with 92 deaths. In 1 case the date was not given.

Negative Cases.

The reported cases in which a negative result was obtained were 76, and the deaths of these were 9, or 11.8 per cent.

Sex. — The males were 33, with 4 deaths, or 12.1 per cent.; and the females were 43, with 5 deaths, or 11.6 per cent.

Age. — The percentage of fatality at each of four age periods was as follows: 0 to 2 years, 9 cases, with 3 deaths, or 33.3 per cent.; 2 to 5 years, 14 cases, with 1 death, or 7.1 per cent.; 5 to 10 years, 20 cases, with 3 deaths, or 15 per cent.; over 10 years, 28 cases, with no deaths.

Summary of the Ten Years and Six Months ended Sept. 30, 1905.

Positive Cases treated with Antitoxin.

Whole number of positive cases for the ten years and six months, 15,016; deaths, 1,445; fatality, 9.6 per cent.

Sex. — The fatality by sexes was as follows: —

Sex.	Cases.	Deaths.	Fatality (Per Cent.).
Males,	7,050	720	10.2
Females,	7,868	709	9.0
Not stated,	98	16	-

Ages. — The fatality by ages was as follows: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	1,551	354	22.8
2 to 5 years,	4,566	581	12.7
5 to 10 years,	4,463	315	7.1
Over 10 years,	3,970	136	3.4
Age unknown,	466	59	-

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals,	10,949	1,154	10.5 [1]
In private practice,	4,067	291	7.2 [1]

[1] This apparent difference in the fatality of hospital and of general or outside treatment with antitoxin is accounted for by the fact that a considerable number of severe and fatal cases of diphtheria, which were treated by physicians in general practice, were reported as having been transferred to a hospital after one or more days of home treatment, and died at the hospital.

Cases in which no Bacteriological Examination was made during the Year ended Sept. 30, 1905.

Reports were received of 276 cases where antitoxin was employed in which no cultures were taken. Of this number, 250, or 90.6 per cent., occurred in general practice, and the remainder were reported from hospitals. Of the whole number, 37, or 13.4 per cent., proved fatal.

Sex. — The number of males in this class was 105, and the deaths of these were 12, or 11.4 per cent. The number of females was 169, and the

deaths of these were 25, or 14.8 per cent. The number of those whose sex was unknown or not stated was 2.

Age. — The following table presents the cases and fatality by ages among this class, so far as observations were made: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
From 0 to 2 years,	21	6 [1]	28.6
From 2 to 5 years,	74	15 [2]	20.3
From 5 to 10 years,	98	10 [3]	10.2
Over 10 years,	75	5	6.6
Unknown,	8	1	–

[1] One case broncho-pneumonia; 1 septicæmia.
[2] One case stenosis of bronchi; 1 case pneumonia; 1 case suffocation; 2 cases septicæmia.
[3] One case hemorrhage of mucous surfaces; 1 case septicæmia.

Sequelæ.

Temporary skin eruptions, usually of brief duration, are of very common occurrence after the administration of antitoxin. Frequently these eruptions are quite mild, and confined to a small area adjoining the place of injection; while occasional instances occur in which the eruption spreads throughout the entire surface of the body, or at least a portion of its area.

During the year under consideration such eruptions or rashes were reported as occurring in 713 instances, or 44.1 per cent. of the whole number reported upon. Of this number, 87.2 per cent. were mild in character, and the remainder severe or extensive.

Albuminuria was reported in 105 cases, in 92 of which the amount of albumen was slight or a trace. The presence of albuminuria, however, has no significance as relating to the administration of antitoxin, since albuminuria is present, according to good authorities, in the majority of severe cases of diphtheria.[1]

Operations.

Tracheotomy, an operation which once was quite commonly resorted to in severe cases of laryngeal diphtheria, appears largely to have been supplanted by the more safe and simple operation of intubation. It is reported as having been performed 12 times during the year, with 7 deaths.

Intubation is reported as having been performed 153 times, with 54 deaths, or 35.3 per cent.

[1] Osler's "Practice of Medicine," second edition, page 115.

The different diseases which are met with as complications of diphtheria independently of the use of antitoxin appear to depend for their frequency largely upon the relative prevalence of these diseases throughout the State. In the year, Sept. 30, 1904, to Sept. 30, 1905, scarlet fever was reported as a complication in 4 instances and measles in 2. In most cases the complication adds to the severity of the cases and increases the fatality, but not to so great an extent as when pneumonia supervenes. Pneumonia and broncho-pneumonia were reported as complications in 12 cases, 10 of which proved fatal.

The most important lesson, repeated in former reports, to which the experience of each successive year adds emphasis, is the necessity of the early administration of antitoxin in each and every case.

Immunization.

Returns of cases in which antitoxin had been used for the purpose of the immunization of persons who had been exposed to the infection of diphtheria were received in 517 cases. Of this number, 458 had been exposed to diphtheria, and had been immunized in the isolation wards of the Boston City Hospital, and chiefly in the scarlet fever ward.

Out of the whole number of 517 thus immunized, 35 or 6.8 per cent., were reported as having contracted diphtheria at some time within two months after immunization.

Of these cases, 1 was found to have diphtheria on the sixth day after immunization, 1 on the eleventh day, 1 on the twenty-first, 2 on the twenty-second, 1 on the twenty-sixth, 1 on the thirty-first, 2 on the thirty-sixth, 2 on the forty-second, 1 on the forty-fifth, 1 on the forty-seventh, 1 on the forty-eighth, 1 on the fiftieth, and in 20 cases the interval was not stated.

In the 203 cases in which a bacteriological examination was made, and in all of which a negative result was obtained, there were 186 cases in hospitals, with 5 deaths, or 2.7 per cent.; and 17 cases in private practice, with no deaths.

The following table presents these cases and fatality by ages: —

In Hospitals.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	8	1	12.5
2 to 5 years,	54	2	3.7
5 to 10 years,	81	–	–
10 and over,	40	2	5.0
Unknown,	3	–	–

In the above 186 cases, scarlet fever developed in 175, or 94.1 per cent.

Private Practice.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	3	-	-
2 to 5 years,	4	-	-
5 to 10 years,	5	-	-
Over 10 years,	5	-	-

The amount of antitoxin administered was as follows: —

In Hospitals.

Dose.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 1,000 units,	4	-	-
1,000 to 1,500 units,	3	-	-
2,000 to 3,000 units,	153	4	-
3,000 to 4,000 units,	2	-	-
4,000 to 5,000 units,	3	-	-
5,000 to 10,000 units,	4	1	-
10,000 to 15,000 units,	1	-	-
Unknown,	16	-	-

Private Practice.

0 to 1,000 units,	3	-	-
1,000 to 1,500 units,	2	-	-
1,500 to 2,000 units,	8	-	-
2,000 to 3,000 units,	1	-	-
3,000 to 4,000 units,	3	-	-

Cases in which no Bacteriological Examination was made.

Of the 314 cases in which no bacteriological examination was made, 216 cases were reported from hospitals, with 13 deaths, or 6 per cent.; and 98 from private practice, with no deaths.

The following tables present the cases and fatality by ages: —

In Hospitals.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	7	3	42.9
2 to 5 years,	53	5	10.4
5 to 10 years,	96	4	4.2
Over 10 years,	51	-	-
Unknown,	9	1	11.1

In the above 216 cases, scarlet fever developed in 178 cases, or 82.4 per cent.; measles in 2 cases, or 0.9 per cent. Other complications were arthralgia, varicella and septic infection: —

Private Practice.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	3	–	–
2 to 5 years,	7	–	–
5 to 10 years,	16	–	–
Over 10 years,	14	–	–
Unknown,	2	–	–

Fifty-six cases were reported from one institution as from four to sixteen years of age.

The amount of antitoxin administered in each case was as follows: —

In Hospitals.

Dose.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 1,000 units,	12	–	–
1,000 to 1,500 units,	27	–	–
2,000 to 3,000 units,	163	11	–
3,000 to 4,000 units,	5	–	–
4,000 to 5,000 units,	5	1	–
10,000 to 15,000 units,	3	1	–
Unknown,	1	–	–

Private Practice.

Dose.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 1,000 units,	9	–	–
1,000 to 1,500 units,	5	–	–
1,500 to 2,000 units,	81	–	–
2,000 to 3,000 units,	1	–	–
3,000 to 4,000 units,	1	–	–
Unknown,	1	–	–

Seasons of the Year. — The cases embraced in the foregoing enumeration occurred in the following order: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
1904.			**1905.**		
October,	47	1	March,	46	2
November,	39	–	April,	43	2
December,	42	2	May,	43	4
			June,	40	1
1905.			July,	26	1
January,	53	3	August,	59	–
February,	42	1	September,	3	–
	–	–		214	8

There were 34 cases, including 1 death, in which the date was not given.

General Summary, 1895–1905.

Positive cases treated in the ten years and six months ended Sept. 30, 1905, and reported to the State Board of Health,	15,016
Cases in which no bacteriological examination was made,	3,634
Total,	18,650 [1]
Deaths of these,	1,908
Fatality (per cent),	10.2

Sexes.

The number of males who were treated was [2]	8,666
The number of females who were treated was [2]	9,807
The number whose sex was not stated was [2]	177
Total,	18,650 [1]
Deaths of males,	939
Fatality of males (per cent.),	10.8
Deaths of females,	944
Fatality of females (per cent.),	9.6
Deaths, sex not stated,	31

The following table contains the results of those cases only which had been determined by a culture examination to be positive, with reference to the fatality of the disease in each group of cases, considered in relation to the stage of the disease when antitoxin was first administered.

Nothing can be more conclusive than the cumulative testimony of these figures, supported, as they are, by similar experience elsewhere, as to the importance of the earliest possible administration of antitoxin in the treatment of diphtheria. Each day's delay renders the liability to a fatal result greater.

The fatality of the cases which were treated with antitoxin very early in the course of the disease (that is, before the termination of forty-eight hours from its onset) was only 6.2 [3] per cent., or 367 deaths in 5,915 cases; while that of the cases which were not thus treated until the sixth day or later was as high as 17 per cent., or nearly three times as great.

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[1] In this number (18,650), 1,669 cases in which a bacterial diagnosis showed negative results are not included, so that the whole number treated with antitoxin of which returns were made to the Board was 20,319.

[2] Except cases determined to be "negative."

[3] The sum of the experience of the first two days is expressed in this figure.

Day of Administration.

Day.	Cases.	Deaths.	Fatality (Per Cent.).
First,	1,717	127	7.4
Second,	4,198	240	5.7
Third,	3,418	302	8.8
Fourth,	2,181	271	12.4
Fifth,	1,133	174	15.3
Sixth and later,	1,599	268	16.7

A considerable number of cases and deaths, in which the day of administration was not stated in the returns, is excluded from this table.

Cerebro-Spinal Meningitis.

There were 28 cases, with 18 deaths, or 64.3 per cent. Bacteriological examinations showed 10 positive cases, with 9 deaths, or 90 per cent.; 3 negative cases, with 1 death, or 33.3 per cent.; and there were 15 cases in which no bacteriological examination was made, with 8 deaths, or 53.3 per cent.

The ages of these 28 cases were as follows: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	2	2	100.0
2 to 5 years,	3	2	66.7
5 to 10 years,	4	1	25.0
10 and over,	18	12	66.7
Unknown,	1	1	100.0

There were 14 males, with 10 deaths, or 71.4 per cent.; and 14 females, with 8 deaths, or 57.1 per cent.

The day of illness on which antitoxin was first administered was as follows: —

Day.	Cases.	Deaths.	Fatality (Per Cent.).
First,	3	2	66.7
Second,	7	6	85.7
Third,	7	2	28.5
Fourth,	5	3	60.0
Fifth,	1	1	100.0
Sixth,	3	2	66.7
Seventh,	1	1	100.0
Unknown,	1	1	100.0

The amount of antitoxin administered in each case was as follows: —

Dose.	Cases.	Deaths.	Fatality (Per Cent.).
3,000 to 4,000 units,	3	2	66.7
4,000 to 5,000 units,	1	1	100.0
5,000 to 10,000 units,	7	4	57.1
10,000 to 15,000 units,	1	1	100.0
15,000 to 20,000 units,	6	4	66.7
20,000 units and over,	10	6	60.0

In 9 cases no appreciable effect from the use of antitoxin was reported; in 1 case each pneumonia and tubercular meningitis were reported; in 2 cases, one a recovery and the other a death, reduction of temperature was reported after the use of antitoxin; and in 1 case, temporary amelioration after each dose of antitoxin. The operation of lumbar puncture was performed in 4 cases.

These 28 cases occurred in the following order: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
1904.			**1905.**		
October,	-	-	April,	13	9
November,	-	-	May,	1	1
December,	-	-	June,	-	-
1905.			July,	-	-
January,	-	-	August,	-	-
February,	1	1	September,	1	1
March,	12	6		15	11
	13	7			

Report upon Diphtheria Cultures examined during the Year ended Sept. 30, 1905.

During the year ended Sept. 30, 1905, 3,382 cultures have been received from 128 towns and cities in the State. Of these cultures, 1,375 were made for the purpose of diagnosis, 2,005 for release from quarantine and 2 were unclassified. Of the cultures made for diagnosis, the bacteriological diagnosis was positive in 492, negative in 870 and doubtful in 13 cases. The following table gives the number of cultures received from the different towns and cities and the results of the examinations: —

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Abington,	2	-	2	-	-
Adams,	7	1	4	-	2
Andover,	5	2	3	-	-
Arlington,	42	5	12	-	25
Athol,	4	2	1	-	1
Attleborough,	10	3	5	-	2
Avon,	2	-	2	-	-
Barnstable,	1	-	1	-	-
Becket,	1	-	-	-	1
Bedford,	29	3	2	-	24
Belmont,	7	2	3	-	2
Beverly,	86	20	17	-	49
Billerica,	3	1	-	-	2
Blackstone,	1	-	1	-	-
Bolton,	1	-	1	-	-
Boston,	1	-	1	-	-
Boxborough,	2	2	-	-	-
Braintree,	4	1	3	-	-
Brewster,	1	-	-	-	1
Canton,	1	-	-	-	1
Carlisle,	2	-	2	-	-

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Charlton,	1	–	1	–	–
Chelsea,	52	12	16	1	23
Cheshire,	4	–	–	–	4
Clarksburg,	2	–	1	–	1
Clinton,	32	14	7	–	11
Cohasset,	48	11	10	1	26
Colrain,	2	–	2	–	–
Concord,	16	6	6	–	4
Cottage City,	2	1	–	–	1
Danvers,	74	16	10	–	48
Dedham,	16	1	14	–	1
Dennis,	2	1	–	–	1
Dover,	1	1	–	–	–
Duxbury,	2	–	2	–	–
East Bridgewater,	14	3	7	–	4
Easton,	10	1	3	–	6
Everett,	108	19	22	–	67
Falmouth,	24	3	1	–	20
Foxborough,	22	2	18	–	2
Framingham,	7	2	4	–	1
Gill,	1	–	1	–	–
Gloucester,	5	2	–	–	3
Great Barrington,	3	1	1	–	1
Groton,	1	–	1	–	–
Groveland,	2	1	1	–	–
Hanson,	1	–	1	–	–
Haverhill,	14	3	10	–	1
Hingham,	20	3	11	–	6
Holbrook,	10	1	8	–	1
Hopkinton,	4	–	4	–	–
Hull,	13	1	8	–	4
Hyde Park,	43	5	14	–	24
Ipswich,	2	–	–	–	2
Kingston,	2	–	2	–	–
Lancaster,	5	1	–	–	4
Lawrence,	20	4	–	–	16
Lincoln,	1	–	1	–	–
Littleton,	1	–	1	–	–

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Ludlow,	8	-	-	-	8
Malden,	236	26	23	1	186
Mansfield,	22	2	7	1	12
Marblehead,	67	15	23	-	29
Marlborough,	32	3	16	-	13
Marshfield,	1	-	1	-	-
Medfield,	8	-	5	-	3
Medford,	113	16	45	-	52
Melrose,	62	9	14	2	37
Methuen,	3	1	2	-	-
Middleborough,	4	2	2	-	-
Millis,	2	-	2	-	-
Milton,	37	3	13	-	21
Monson,	1	-	-	-	1
Natick,	10	2	8	-	-
Needham,	5	-	5	-	-
Newbury,	4	-	-	-	4
Newburyport,	69	13	36	-	20
Norfolk,	1	-	1	-	-
North Adams,	279	39	39	2	199
North Attleborough,	11	3	7	1	-
North Reading,	12	2	6	-	4
Norwell,	14	3	2	-	9
Norwood,	9	5	4	-	-
Oakham,	6	2	-	-	4
Orange,	2	-	-	-	2
Peabody,	46	2	19	-	25
Plymouth,	12	7	4	-	1
Princeton,	2	-	2	-	-
Provincetown,	15	7	3	-	5
Quincy,	66	22	32	-	12
Randolph,	2	-	2	-	-
Reading,	29	6	13	-	10
Revere,	27	3	20	-	4
Rockland,	14	2	5	-	7
Salem,	450	27	22	-	401
Saugus,	95	15	39	-	41
Scituate,	16	2	8	-	6

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Shelburne,	2	1	1	-	-
Sherborn,	1	-	1	-	-
Shirley,	2	-	2	-	-
Southborough,	4	1	2	-	1
Southbridge,	206	10	13	-	183
Southwick,	1	-	1	-	-
Spencer,	17	1	-	-	16
Stoneham,	12	-	10	2	-
Stoughton,	8	2	4	-	2
Swampscott,	5	-	4	-	1
Taunton,	38	10	16	-	12
Topsfield,	12	2	1	-	9
Wakefield,	17	3	5	-	9
Walpole,	3	-	3	-	-
Ware,	8	1	7	-	-
Warren,	11	2	4	-	5
Watertown,	251	32	24	-	195
Wayland,	2	-	2	-	-
Wellesley,	2	-	2	-	-
Wenham,	5	1	-	-	4
Westfield,	5	3	1	-	1
Westford,	4	-	4	-	-
Westwood,	1	-	1	-	-
Weymouth,	19	2	14	1	2
Williamsburg,	1	-	1	-	-
Williamstown,	2	-	1	1	-
Wilmington,	4	1	2	-	1
Winchester,	63	7	40	-	16
Winthrop,	35	6	10	-	19
Woburn,	46	11	14	-	21
Wrentham,	2	-	2	-	-
Unclassified,	2	-	-	-	-
Total,	3,382	492	870	13	2,005

Summary.

The whole number of cultures examined since the bacteriological diagnosis of diphtheria was undertaken by the Board is as follows: —

In 1896-1897 (year ended March 31, 1897),	1,469
In 1897-1898 (year ended March 31, 1898),	2,204
In 1898-1899 (year ended March 31, 1899),	1,591
In 1899-1900 (year ended March 31, 1900),	3,258
In 1900-1901 (year ended March 31, 1901),	5,173
In 1901-1902 (year ended March 31, 1902),	4,119
In 1902-1903 (year ended March 31, 1903),	2,904
In 1903-1904 (year ended March 31, 1904),	3,632
In 1904 (from April 1 to Sept. 30, inclusive),	1,014
In 1904-1905 (year ended Sept. 30, 1905),	3,382
Total,	28,746

REPORT UPON THE EXAMINATION OF SPUTUM AND OTHER MATERIAL SUSPECTED OF CONTAINING THE BACILLI OF TUBERCULOSIS.

During the year ended Sept. 30, 1905, microscopical examination has been made of 1,090 samples of sputum and other material suspected of containing the bacilli of tuberculosis. This material has been received from 143 different towns and cities in the State. Of these 1,090 samples, 1,083 are supposed to be for primary examination and 7 are stated to be for re-examination. Of the 1,083 samples for primary examination, the bacilli of tuberculosis were found in 367 and not found in 709 samples, and examination was not made of 7 samples because of broken or leaky receptacles. The following table gives the places from which the material was received and the results of the examinations: —

City or Town.	Whole Number of Examinations.	Positive.	Negative.	Doubtful.	Re-examinations.	City or Town.	Whole Number of Examinations.	Positive.	Negative.	Doubtful.	Re-examinations.
Abington,	2	-	2	-	-	Braintree,	9	3	6	-	-
Adams,	7	4	3	-	-	Bridgewater,	7	3	3	-	1
Andover,	3	-	3	-	-	Brockton,	2	-	2	-	-
Arlington,	11	1	10	-	-	Brookfield,	1	1	-	-	-
Ashland,	6	1	5	-	-	Burlington,	1	-	1	-	-
Athol,	2	-	1	-	1	Cambridge,	3	-	3	-	-
Attleborough,	9	1	8	-	-	Chelsea,	12	6	5	1	-
Ayer,	1	-	1	-	-	Clinton,	3	2	1	-	-
Barnstable,	1	-	1	-	-	Cohasset,	3	1	2	-	-
Barre,	1	-	1	-	-	Concord,	7	2	5	-	-
Bedford,	1	-	1	-	-	Concord, Massachusetts Reformatory.	5	2	3	-	-
Belmont,	1	-	1	-	-	Danvers,	10	2	8	-	-
Beverly,	2	1	1	-	-	Dedham,	12	5	7	-	-
Blackstone,	13	5	8	-	-	Dover,	1	-	1	-	-
Boston,	3	-	3	-	-	Easton,	1	-	1	-	-
Boxford,	1	-	1	-	-	East Bridgewater,	7	3	4	-	-

City or Town.	Whole Number of Examinations.	Positive.	Negative.	Doubtful.	Re-examinations.
Everett,	51	20	31	–	–
Fall River,	156	75	81	–	–
Foxborough,	14	2	12	–	–
Framingham,	16	2	14	–	–
Franklin,	3	–	3	–	–
Freetown,	1	1	–	–	–
Gloucester,	5	3	2	–	–
Great Barrington,	2	–	2	–	–
Greenfield,	9	2	7	–	–
Groton,	1	–	1	–	–
Halifax,	2	–	2	–	–
Hamilton,	1	1	–	–	–
Hanover,	4	–	4	–	–
Haverhill,	3	1	2	–	–
Hingham,	6	–	6	–	–
Holbrook,	3	–	3	–	–
Holden,	6	1	5	–	–
Hopkinton,	1	–	1	–	–
Hull,	6	–	6	–	–
Hyde Park,	11	7	4	–	–
Ipswich,	6	1	5	–	–
Lawrence,	41	18	22	1	–
Lexington,	11	6	5	–	–
Lincoln,	1	1	–	–	–
Littleton,	3	1	2	–	–
Lynn,	1	1	–	–	–
Lynnfield,	1	–	1	–	–
Malden,	12	3	9	–	–
Mansfield,	13	3	10	–	–
Marion,	1	1	–	–	–
Marlborough,	17	6	11	–	–
Marshfield,	7	2	5	–	–
Maynard,	1	1	–	–	–
Medford,	19	1	17	1	–
Melrose,	31	7	24	–	–
Methuen,	2	–	2	–	–
Middleborough,	3	1	2	–	–
Milford,	2	1	1	–	–
Millis,	2	1	1	–	–
Milton,	5	–	5	–	–
Montague,	1	–	1	–	–
Natick,	21	10	11	–	–
Needham,	7	–	7	–	–
Newburyport,	2	2	–	–	–
Newton,	2	1	1	–	–
North Adams,	54	19	35	–	–
North Attleborough,	18	3	15	–	–
North Brookfield,	1	–	1	–	–
Northfield,	4	–	4	–	–
Norton,	5	2	3	–	–
Norwell,	1	–	1	–	–
Norwood,	6	1	5	–	–
Orange,	1	–	1	–	–
Oxford,	2	1	1	–	–
Peabody,	34	15	19	–	–
Plymouth,	3	1	2	–	–
Provincetown,	3	2	1	–	–
Quincy,	40	17	23	–	–
Randolph,	19	4	14	–	1
Raynham,	2	2	–	–	–
Reading,	8	1	7	–	–
Revere,	8	3	5	–	–
Rockland,	10	2	8	–	–
Salem,	30	12	17	–	1
Saugus,	7	5	2	–	–
Scituate,	2	1	1	–	–
Shelburne,	1	–	1	–	–
Sherborn,	2	1	1	–	–
Shirley,	7	3	4	–	–
Somerville,	1	–	1	–	–
Southborough,	1	–	1	–	–
Spencer,	5	–	5	–	–
Sterling,	1	–	1	–	–
Swampscott,	1	–	1	–	–

City or Town.	Whole Number of Examinations.	Positive.	Negative.	Doubtful.	Re-examinations.	City or Town.	Whole Number of Examinations.	Positive.	Negative.	Doubtful.	Re-examinations.
Swansea, ...	1	–	1	–	–	Westport, ...	1	1	–	–	–
Taunton, ...	37	15	21	1	–	Weymouth, ...	6	1	5	–	–
Topsfield, ...	1	–	1	–	–	Whitman, ...	5	3	2	–	–
Townsend, ...	1	1	–	–	–	Williamsburg, . .	1	–	1	–	–
Wakefield, ...	1	–	1	–	–	Williamstown, . .	3	–	3	–	–
Walpole, ...	6	3	3	–	–	Wilmington, ...	7	3	4	–	–
Warren, ...	5	1	4	–	–	Winchendon, ...	2	1	1	–	–
Watertown, ...	3	2	1	–	–	Winchester, . . .	25	5	20	–	–
Wayland, ...	2	1	1	–	–	Winthrop, ...	6	1	5	–	–
Wellesley, ...	4	2	2	–	–	Woburn, ...	10	3	7	–	–
Westborough, . . .	2	1	1	–	–	Worthington, ...	4	–	4	–	–
West Brookfield, . .	1	–	1	–	–	Wrentham, ...	1	1	–	–	–
Westford, ...	8	1	7	–	–	Unclassified, ...	5	–	1	1	3
West Newbury, . .	1	–	1	–	–	Total, . . .	1,090	367	709	7	7
Weston, ...	3	–	1	2	–						

Summary.

The number of samples of sputum and other material examined for the bacilli of tuberculosis since these examinations were undertaken by the Board is as follows: —

In 1896–1897 (year ended March 31, 1897), ...	124
In 1897–1898 (year ended March 31, 1898), ...	236
In 1898–1899 (year ended March 31, 1899), ...	414
In 1899–1900 (year ended March 31, 1900), ...	571
In 1900–1901 (year ended March 31, 1901), ...	746
In 1901–1902 (year ended March 31, 1902), ...	797
In 1902–1903 (year ended March 31, 1903), ...	928
In 1903–1904 (year ended March 31, 1904), ...	1,006
In 1904 (from April 1 to Sept. 30, inclusive), ...	494
In 1904–1905 (year ended Sept. 30, 1905), ...	1,090
Total, ...	6,406

TYPHOID FEVER.

Widal, Agglutinative or Serum Test.

During the year ended Sept. 30, 1905, 459 specimens of blood were subjected to the widal or agglutinative test for typhoid fever, the method employed being substantially the same as that described in the report for 1900. The dilution used is equivalent to 1 part of fluid blood to 20 of a bouillon culture of typhoid bacilli, or 1 part of blood serum to about 35 of culture fluid.

The blood specimens examined are given in the two following tables. In the first they are grouped according to towns. The whole number of specimens received is given, and divided into positive and negative, according to the outcome of the test. Eighy-eight cities and towns sent specimens to the laboratory, of which 89, or about 19.4 per cent., were positive.

In the second table the results of the examination are arranged according to the day of the disease on which the blood was collected. From this table it will be seen that positive cases were most numerous after the sixth day of the disease. Since the agglutination-reaction may not appear until the second week of the disease, or even later, the blood of cases examined with negative result during the first week should be again examined in the second or third week.

Widal Test, Oct. 1, 1904, to Sept. 30, 1905.

City or Town.	Number of Cases.	Positive.	Negative.	City or Town.	Number of Cases.	Positive.	Negative.
Abington,	2	1	1	Danvers,	6	2	4
Arlington,	1	–	1	Dartmouth,	1	–	1
Attleborough,	13	1	12	Dedham,	1	–	1
Ayer,	4	2	2	Dighton,	2	–	2
Bedford,	3	2	1	East Weymouth,	5	–	5
Belmont,	2	–	2	Everett,	20	3	17
Beverly,	6	2	4	Fall River,	1	–	1
Boston,	1	–	1	Foxborough,	1	–	1
Brockton,	1	–	1	Franklin,	1	–	1
Cambridge,	3	1	2	Groton,	1	–	1
Canton,	3	–	3	Haverhill,	2	–	2
Clinton,	2	–	2	Hingham,	2	–	2
Concord,	4	1	3	Holden,	17	3	14
Cottage City,	1	1	–	Hull,	3	–	3
Chelsea,	10	1	9	Hyde Park,	14	3	11
Cochituate,	2	–	2	Lancaster,	1	–	1

Widal Test, Oct. 1, 1904, to Sept. 30, 1905 — Concluded.

City or Town.	Number of Cases.	Positive.	Negative.	City or Town.	Number of Cases.	Positive.	Negative.
Lawrence,	4	–	4	Salem,	2	–	2
Leominster,	6	1	5	Salisbury,	1	–	1
Lynn,	71	22	49	Saugus,	4	2	2
Lynnfield,	1	–	1	Scituate,	5	1	4
Malden,	3	–	3	Shirley,	2	–	2
Marlborough,	4	2	2	Somerville,	5	1	4
Marshfield,	1	–	1	South Hanson,	1	–	1
Medford,	13	–	13	Southborough,	2	1	1
Melrose,	8	–	8	Stoughton,	4	–	4
Middleborough,	1	–	1	Sudbury,	1	–	1
Middleton,	1	–	1	Swampscott,	7	1	6
Natick,	3	1	2	Taunton,	3	–	3
Needham,	9	1	8	Topsfield,	2	–	2
Newburyport,	37	11	26	Wakefield,	1	1	–
North Adams,	4	1	3	Waltham,	4	–	4
North Easton,	2	–	2	Watertown,	2	–	2
Norwood,	5	2	3	Wellesley,	1	–	1
Osterville,	3	–	3	Wenham,	2	1	1
Peabody,	1	–	1	Westfield,	12	3	9
Pepperell,	1	–	1	Westford,	2	2	–
Plymouth,	1	1	–	Westport,	1	–	1
Quincy,	2	1	1	Whitman,	1	–	1
Randolph,	1	–	1	Williamstown,	4	–	4
Reading,	18	2	16	Winchester,	25	1	24
Revere,	14	4	10	Winthrop,	6	2	4
Rockland,	2	–	2	Woburn,	2	–	2
Rockport,	1	–	1	Wollaston,	2	–	2
Rowley,	1	1	–				
Rutland,	1	–	1	Total,	459	89	370

Widal Test, according to Stage of Disease, Oct. 1, 1904, to Sept. 30, 1905.

Approximate Number of Days from Beginning of Disease to Collection of Blood.	Number of Cases.		Approximate Number of Days from Beginning of Disease to Collection of Blood.	Number of Cases.	
	Positive.	Negative.		Positive.	Negative.
2,	–	2	23,	3	4
3,	1 (?)	7	24,	–	5
4,	–	9	26,	1	2
5,	–	13	27,	1	–
6,	4	21	28,	–	2
7,	5	36	29,	–	1
8,	1	28	30,	–	1
9,	7	14	31,	–	1
10,	7	23	34,	2	1
11,	4	23	35,	1	–
12,	2	15	37,	–	1
13,	4	8	39,	–	1
14,	6	30	42,	–	2
15,	3	9	44,	–	1
16,	5	6	54,	–	1
17,	3	6	62,	–	1
18,	5	9	75,	–	1
19,	1	–	118,	1	–
20,	1	6	Unknown,	19	61
21,	2	13			
22,	–	6	Total,	89	370

MALARIA.

The number of blood films received by the laboratory during the year ended Sept. 30, 1905, for microscopic diagnosis, was 21, of which only 1, or about 4.8 per cent., showed the malaria parasite.

Malaria, Oct. 1, 1904, to Sept. 30, 1905.

City or Town.	Number of Cases.	Positive.	Negative.
Chelmsford,	1	-	1
Melrose,	2	-	2
Norwood,	1	-	1
Quincy,	1	-	1
Waltham,	2	-	2
Westfield,	2	-	2
Weston,	1	-	1
West Roxbury,	1	1	-
Winchester,	9	-	9
Wollaston,	1	-	1
Total,	21	1	20

Report upon Investigation

of

Local Outbreaks of Infective Diseases.

Report upon Investigation of Local Outbreaks of Infective Diseases.

Following is an account of the local outbreaks of infective diseases in which the assistance of the Board was invoked: —

Amesbury. — Forty-three cases of scarlet fever occurred in this place in December, 1904. Investigation showed that all of the patients obtained their milk from a common source, a farmer who kept 30 cows and supplied 230 quarts of milk daily to 200 customers. The milking was done by the farmer himself, assisted by two sons and three hired men. The milk was strained into a 150-quart tank, mixed, and delivered by one of the sons, assisted by one of the hired men, one-half being distributed in bottles, and the remainder in 8-quart cans.

The son who drove the milk wagon was taken sick with scarlet fever in a mild form on the day before that on which the investigation of the epidemic was begun, too late for him to be considered as a source of infection.

Further investigation in the town revealed that two other cases of scarlet fever in a mild and unrecognized form had existed in families supplied with milk by this dealer, one case dating back to November 21 and the other to December 3. The first of these cases, a boy eight years old, was taken ill November 3, with sore throat followed by an eruption. His illness was so slight that a physician was not called. When seen by the representative of the State Board of Health he was desquamating upon his hands, and had a well-marked strawberry tongue. Two other members of the same family also had scarlet fever at this time.

The other case was a girl nine years old. When seen, she was desquamating after a typical attack of the disease, unrecognized by the physician in attendance.

In the light of these two cases, it seems possible that the spread of the disease took place through milk as a medium, either by infection of the jars in which the milk was supplied, or by the transference of contagion by the milk distributors themselves.

The local board of health was notified of the conditions disclosed by investigation, and was advised to prevent the distribution of milk from this source for a period sufficient to eliminate the danger of infection.

The local Board was advised to secure the sterilization of the different milking utensils, to instruct the milkman to take no bottles from houses where scarlet fever had existed, and to allow no one concerned with the care of any scarlet fever patient to handle any milking utensils.

The disease continued to develop, but less extensively than previously. In the last week of December, 5 cases only were reported, and following these none appeared until January 17, when 3 cases occurred, in no way attributable to the use of infected milk. The epidemic continued, greatly diminished, during February and March.

Bedford. — During the month of September, 1905, 7 cases of typhoid fever were reported in Bedford, — a town which for many years had been free from the disease. The earliest of these cases were reported September 7. Both were men, Danes, in the employ of W. L., a farmer, and boarders of P., a retail milk dealer. They were taken sick September 1, and were sent to a Boston hospital for treatment. Both had been residents of Bedford for about six weeks. One of them had been milking for the farmer, W. L. Two other persons were taken ill about September 1, each of whom had been supplied with milk by a dealer who obtained a portion of his supply from W. L.

Investigation showed that the milk dealer, P., had been ill, and had returned to his work September 7, and according to the statement of his physician he had no fever. From other sources of information it was learned that this man was reported to have had "slow fever." No cases of typhoid fever had been reported among his customers. Later in the month 3 other cases of typhoid fever were discovered, one of which was in the family of a farmer who supplied milk to the retailer, P., among whose customers occurred 2 of the cases already referred to.

The information obtainable regarding this epidemic was rather meagre, but it seems probable that it originated with a man in whose family boarded two employees of a milk contractor among whose customers occurred 3 of the 7 cases reported.

Blandford. — In August, 1905, 6 cases of typhoid fever occurred in Blandford, 4 of which were in a boarding house, and a fifth was associated with certain of the boarders in this house. This last-mentioned patient was a farmer who kept 3 cows, and supplied cream to the Springfield Co-operative Milk Association. The proprietor of the boarding house was likewise a farmer who kept 9 cows, and also supplied cream to the association. This disposition of the cream was discontinued after the outbreak of the disease. It was learned subsequently that later the cream was sent to Holyoke and used in the manufacture of ice cream.

Chelsea and Everett. — Information was laid before the secretary early in August concerning a series of cases of typhoid fever which had oc-

curred among persons connected with a day nursery in Chelsea, and it was suggested that the source of the infection might be found to be the milk supplied by a dealer whose place of business and milk production was in Everett. In consequence of the information submitted, the premises of the milkman were visited. In a stable having but 7,000 cubic feet of air space were found 26 filthy cows, kept under revolting conditions. They were bedded in horse manure, and their air supply was largely from the cellar, in which liquid manure was standing in large pools, emitting an almost overpowering stench. The milk of these filthy cows was being handled in a dirty milk-room, where the bottles and cans employed in the business received what passed for a cleaning process.

The amount of milk produced daily was about 300 quarts, all of which was sold in Everett and Chelsea.

There was no history of typhoid fever in the family of the milkman or among the persons employed by him, but investigation showed that practically all of the houses in Everett invaded by typhoid fever were supplied by him with milk. In 3 families supplied exclusively by him there existed no fewer than 10 cases.

Chester. — During the early part of November, 1904, the reports of infectious diseases received from the town of Chester showed typhoid fever to be unusually prevalent. No cases of this disease had been reported during the first ten months of the year. On November 15 a visit was made to the town, in order to determine, if possible, the source of infection. At this time 9 cases of the disease existed, all of them having developed since October 27. Upon inquiry it was learned that without exception the patients had consumed milk from the same source of supply. It was learned at the farm that 29 cattle yielded 180 quarts of milk daily. During the autumn it occasionally had been necessary for the farmer to buy additional milk, but none had been obtained in this way during the two weeks previous to the investigation, and on only three or four occasions since October 1. The milking and aerating were done by two hired men. The milk was distributed in bottles, the same customer receiving the same bottles each day. The washing of the milking utensils was done by the wife of the milkman, and the bottling by the milkman himself. The milk wagon was driven by one of the hired men who had come to work on October 15. It was learned that he had been ill with typhoid fever after coming to the farm.

In view of the fact that the first case developed on October 27, it would seem that the infection of the milk must have taken place soon after this man came to work. The board of health of the town and the milk dealer were informed of the results of the investigation and of the probable source of infection; and the milkman, in order to protect his own

customers, dismissed the man. After November 11 no further cases were reported. Of the 9 patients, 1 died on November 17.

Easthampton. — Early in October, 1904, information was received by the Board that typhoid fever was unusually prevalent in this place. At that time no cases of the disease had been reported by the local board of health. Investigation showed that between May and October, 13 cases had occurred. The first of these was undoubtedly one in which infection took place out of town. The occurrence of these cases was as follows: 1 in June, 4 in August, 5 in September and 1 in October. In several instances infected persons had been using well water. In 5, the milk supplied had been obtained from the same dealer. Examination of the premises of this dealer disclosed no source of infection.

Investigation of the water supply of the town showed the possibility of sewage pollution from two farms situated on the water-shed of Bassett Brook, and about 100 yards from its banks. Here the overflow from two cesspools flowed directly towards the brook; a crude filter-bed constructed in the path of this overflow was very evidently inefficient.

The attention of the local board of health was called to these conditions.

Ipswich. — Twenty-nine cases of typhoid fever were reported here between September 12 and October 16. Twenty-six of the victims were supplied with milk by the same dealer, who produced his own supply and distributed among about 100 customers. It was learned that he occasionally borrowed milk from milkmen in Rowley. His milk was excluded from the market September 27. Investigation showed his premises to be in fair condition, and that his cans were washed in well water, which, upon analysis by the State Board of Health, was found to be badly polluted and unfit for use. This well was situated 15 feet from the barn cellar, which was undrained. In one corner of the cellar and near the well was a privy frequently used by the passers-by. No illness of any sort had existed during the summer on these premises.

Lynn. — During the five months, June–October, 54 cases of typhoid fever were reported in Lynn, the greater number of which occurred in August and September. Investigation showed that 43 of the victims were supplied by 16 different milk dealers. The milk supply of the others could not be ascertained. The largest number among the customers of any one dealer was 11; 1 other dealer had 5, and 3 other dealers had 4 each among their customers. The source of infection could not be determined, nor was any connection demonstrable between the cases occurring early in the summer and those developing later.

North Oxford. — During the month of September, 30 cases of typhoid fever were reported here, with 3 deaths. All of the cases occurred in a

part of the town occupied by the employees of one of the woolen mills. The milkmen supplying this part of the town supplied also districts free from typhoid fever. The water supply of the infected district was derived from 8 wells, the waters of 6 of which were found on analysis to be so polluted as to be unfit for drinking. The use of the water from these wells for drinking purposes was forbidden by notices posted upon the pumps. Following this, the epidemic declined. Nearly all of the cases developed about two weeks following the heavy rainfall of September 3–4.

Plymouth. — During the month of January, 28 cases of typhoid fever occurred in Plymouth. Up to that time the town had been comparatively free from the disease; in 1903, 10 cases only having been reported, which were scattered throughout the year.

Investigation showed that all of the victims had been living for some time past in Plymouth, and that 27 of them were supplied with milk by the same dealer. Five members of this milk dealer's family were found to have typhoid fever. Inspection of his premises showed that he kept 20 cows in a barn situated about one mile from his house. The milking was done by two of his sons, one of whom was taken ill with typhoid fever on January 9, but continued to work until January 15. The milk was brought to the house, placed in a 100-quart mixing can, cooled, and placed in 8-quart cans for delivery. The greater part of the milk was distributed by measure at the houses of the customers.

With the appearance of the disease in his family the milk dealer voluntarily discontinued the distribution of his milk. This seemed to check the outbreak, for but 2 cases of the disease were reported in the first ten days of February. Four deaths occurred in the course of this epidemic.

During the course of the investigation it was found that the discharges from a patient had been deposited upon the ice of a pond near by. The local board of health asked for advice as to the use and distribution of this ice. Examination of it showed that it contained a larger number of bacteria than is found in ice of good quality. The local board was advised to prevent the use of this ice for domestic purposes.

Increasing prevalence of typhoid fever in Plymouth during July led to further investigation in this town. Between July 7 and July 12, 8 cases occurred among the customers of one milkman. Prior to these, no cases had been reported for three months. This milk dealer kept 4 cows, producing 45 quarts of milk daily, a large part of which was used in the Plymouth hospital. Examination of the premises of this milk dealer revealed no source of infection, nor could such be discovered elsewhere.

Rockland. — Early in January the reports of infectious diseases in

Rockland showed that during the preceding four months an unusual number of cases of typhoid fever had existed in the town. Investigation showed that 5 cases had occurred during the early part of September, and that 1 case was reported on the first day of October and 1 on the 25th. In January, 1 case was reported on the 8th, 2 on the 10th and 1 on the 15th. Nine of the patients obtained milk from the same source. Concerning the other 2, no definite information could be obtained as to the origin of their illness. Inspection of the dairy at Hanover, whence was derived the milk used by these patients, showed that the farmer kept 20 cows, supplying 15 cans daily, and that he bought 5 additional cans from 3 other milk dealers. The farmer and his son did all the work about the barn, including the milking. He was taken ill with typhoid fever September 8, and was confined to his bed for thirty-eight days. Upon recovery he returned to work, doing but little from November 15 through the rest of the month, but attending regularly to his work from December 1.

In view of these facts, it seems probable that the source of infection was at this dairy, contagion having been spread through the medium of milk. The water supply at the farm was obtained from an old well, and in September, by reason of the continued prevalence of typhoid fever, the board of health of the town advised the farmer to discontinue the use of this well. The board of health of the town was advised to see that a good supply of water was obtained at the farm as soon as possible in the spring, in order to prevent further infection of the milk.

In August typhoid fever again appeared in Rockland, 15 cases being reported in the latter half of the month. Investigation showed that all of these cases were traceable directly or indirectly to milk coming from the dairy of C. A. B. of North Hanover. Inspection of this dairy showed a herd of 15 cows kept in a poorly ventilated and lighted stable. The milk was handled in a milk room adjacent to the barn, aerated and cooled with ice, and delivered in Rockland. The milk cans and bottles were washed in the milk room, the drainage from which was conducted to a sand basin, through which it filtered, leaving a semi-solid mass of accumulated residue, sour and foul-smelling. Milk bottles returned from houses where typhoid fever was present were washed in this milk room. The house sink-drain discharged upon the surface of the ground, and foul sewage from this source had accumulated.

Inquiry disclosed that when typhoid fever was prevalent in Rockland, during the early part of the year, the proprietor of this farm had the disease; that after his recovery no disinfection of the premises took place, and that at the time of investigation the same house furnishings and bedding were in use in his room as were there during his illness. Since his recovery this farmer had been constantly employed upon his farm,

himself milking the cows, handling the milk and washing the milking utensils and bottles.

A further investigation of the premises of this farmer, made in the latter part of September, disclosed the fact that within a year three wells had been in use, the water from each of which had been condemned. At this time the local board of health reported diminished prevalence of the disease.

Southbridge. — Seventy-seven cases of diphtheria were reported in this town within the six months, June–November, with 7 deaths. Thirty-eight of these cases occurred after September 1, and were distributed in all parts of the town. Twenty-six patients were children of school age. Of these, 18 were members of the French parochial school, which is attended by about one-half of the entire school population. The representative of the Board who investigated this epidemic reported that the local board of health felt the lack of co-operation upon the part of the authorities of this school, and of certain physicians, this feeling having its origin in the failure on the part of the school authorities to exclude from school those children in whose homes diphtheria existed, and the concealment on the part of certain physicians of cases of the disease. The local board of health was advised to secure compliance with the statutes relating to infectious diseases on the part of the school authorities and of these physicians, — if necessary, with recourse to legal process.

Springfield. — Twelve cases of trichinosis occurred in this city and in Middlefield in the months of January and February, 3 of them Italians living in the same house. The earlier cases included 3 adult males, who were taken sick January 8, with a form of the disease so mild that it was diagnosed as influenza. Two of the cases were cared for at the Almshouse Hospital. Examination of the blood of several of the patients showed a marked degree of eosinophilia.

Investigation showed that on December 27, two swill-fed hogs were slaughtered by an Italian butcher at Agawam, who disposed of the pork to Italian pedlers in Springfield and in West Springfield, from whom it was purchased by the infected family. Sausages made from this pork had been eaten by all of the infected individuals. Examination of the pork showed it to contain trichinæ in large numbers. Its further use was prohibited, and no additional cases of the disease were reported.

During the summer and autumn of 1905, typhoid fever was unusually prevalent in this city, more than 150 cases being reported to the local board of health between July and October. This epidemic was thoroughly investigated, with the result that neither water supply nor milk could be regarded as the vehicle of contagion. The disease was prevalent chiefly among the foreign population, and in the poorer and more unsanitary quarters of the city. The evidence obtained from a study of

this outbreak showed that the spread of the disease was due mainly to contact infection among people of unclean habits, and to the distribution of contagion through the medium of fruits, vegetables and other articles of food, infected during exposure for sale by venders in the parts of the city in which the epidemic originated.

Swampscott and Rowley. — Between August 1 and October 3, 14 cases of typhoid fever were reported in Swampscott. Investigation showed that 11 of these were among the customers of a milk dealer who was distributing about 80 cans of milk a day, chiefly in bottles. This dealer produced no milk himself, but obtained his supply from 7 dairies in Swampscott and Rowley. No source of infection was found upon his premises. Investigation of these dairies disclosed the fact that in the families of the proprietors of 2 of them cases of typhoid fever had recently occurred, 2 in one family and 3 in the other. The first patient was taken sick in August, and recovered after an illness of seven weeks. The majority of the cases in the epidemic occurred in the latter half of September. At one of these dairies it was discovered that a pail used for the removal of the discharges from the patients was kept near the well curb. Water from this well was used in washing the milk utensils. In view of the facts, it seems probable that in this epidemic infection was spread through the milk, and that the source of contagion lay in either one or the other or both of the dairies upon the premises of which typhoid fever had occurred.

Waltham. — During September and October, an extensive outbreak of typhoid fever occurred in this city. At the time of investigation, in October, 86 cases had been reported to the local board of health. The earliest case was reported on August 31. The greater part of the cases occurred between September 15 and October 1. Investigation showed these cases to be very generally distributed throughout the city. Eleven occurred in one boarding house. One-half of the reported cases were found to be among the customers of one milkman, who distributed 60 cans a day to about 700 customers, and who obtained his entire supply from 3 dairies in Lincoln, Weston and Waltham. No source of infection was discovered upon the premises of this milkman, but investigation of the dairies furnishing him with milk disclosed the fact that it may have been present at one of them. At one of these farms it was learned that the proprietor's son, a boy of twelve, had been ill since the middle of August with what competent medical authority, called in consultation in September, regarded as walking typhoid fever. This patient took to his bed early in September, and after September 17 was in charge of a trained nurse, prophylactic measures with respect to discharges and bedding being operative after that date.

The premises at this dairy were found to be generally satisfactory, but a cooling trough situated in a milk shed with a dirt floor was so placed as to be easy of access to any infective material which might have been present on the floor of the shed.

Investigation of 11 cases in a boarding house showed that these occurred at about the same time as the majority of the other cases, and that they were all "primary" cases. The milk used at this house was almost all obtained from a milk dealer among whose customers were no other cases. Some milk was purchased at a store which was supplied by a dealer, among whose customers were but two victims. The vegetables and produce used at this boarding house were raised by the proprietor on his own farm, which upon investigation showed no source of infection.

Nearly all of the infected persons either habitually used or had access to city water. The water used for public supply was upon several occasions submitted to bacteriological examination and found to contain colon bacilli.

The geographical distribution of the cases in this outbreak is not inconsistent with the theory of water-borne infection. The occurrence of a majority of them within a period of about two weeks shows, however, that continuous pollution was improbable.

Westfield. — Between the 6th and the 27th of July, 11 cases of typhoid fever were reported in Westfield. Investigation showed that 8 of the patients obtained their milk from J. F., and that 2 of the remaining 3 had acquired the disease outside of Westfield. Inspection of the premises of the milkman, J. F., showed him to be a distributor of about 600 quarts of milk daily, which he obtained from 10 different dairies, some of the milk being collected by J. F., and the remainder brought to his premises by the producers. Although the conditions upon his premises were somewhat unsatisfactory, there was no evidence that the milk was infected here.

Investigation of the dairies furnishing J. F. with milk disclosed the fact that the proprietor of one of them had recently recovered from a severe attack of typhoid fever. This man himself brought his milk to the premises of J. F.

The local board of health was informed of these conditions and of the probable source of infection, and was advised to restrain the farmer, M., from the handling of milk and milking utensils. The local board was also advised to require improvement in the condition of the premises of J. F.

During the month of August, 21 additional cases of typhoid fever were reported in Westfield.

Early in September further investigation showed that between July

16 and September 11, 38 cases of typhoid fever had been reported to the local board of health; that of the infected persons, 22 were supplied with milk by the same milkman, J. F. Eight of these 38 cases were reported between July 16 and July 31, 19 between August 1 and August 31, and 6 between September 1 and September 11.

Inspection of the premises of J. F. showed at this time a fair degree of cleanliness, and no evidence of infection of the milk here. It was learned that on August 2 the farm of J. A., which up to that time had been a source of milk supply to J. F., had been placed in quarantine by the local board of health, for the reason that the wife of J. A. was reported to the board as a probable case of walking typhoid fever. During quarantine the milk from this farm was used for butter making, the butter being kept upon the premises.

In view of the conditions disclosed by these investigations, it seems probable that this epidemic was due to contagion spread through the medium of milk, the source of infection being double, and referable to the 2 cases of typhoid fever above noted.

Woburn. — In the month of August, 8 cases of typhoid fever were reported here. Investigation showed that 5 of the victims were supplied with milk from the same source. One of them was taken sick in Billerica, and another had visited in the family of J. R., who was employed at the dairy of J. C., one of the sources of supply of the milk dealer among whose customers occurred the majority of the cases. This dairy was found to be in a very unsanitary condition, and it was learned that one of the employees had been ill with typhoid fever. It was recommended that milk from this source be excluded from the market, and that improvement in the sanitary conditions of the premises be required.

Wrentham and Franklin. — At the request of the Wrentham board of health, several cases of typhoid fever in that town were investigated, to determine, if possible, the source of infection. In all, 7 cases were found to have occurred, 4 in a family living in Wrentham and 3 in a related family living in Franklin. The onset of the disease in 6 of these persons occurred within the period August 20–28; the seventh fell ill several weeks later, after nursing two of the victims. All of the persons affected dined together at the home of the Wrentham family on August 6. Other persons who were visiting in the home of this family before and after this date, but who were not there on August 6, did not have cases occurred within the period August 20–28; the seventh fell ill several weeks later, after nursing two of the earlier cases. All of the persons affected dined together at the home of the Wrentham family on August 6. Other persons who were visiting in the home of this family before and after this date, but who were not there on August 6, did not have

the disease. No illness had occurred upon the premises of the Wrentham family prior to the outbreak of typhoid fever. The water used by this family came from a well in the front yard. Analysis of this water showed it to be slightly polluted. The family obtained milk from a neighbor who supplied other people in the vicinity, and whose premises showed no source of infection. No oysters or other shellfish and no ice cream were eaten by the infected persons on August 6, nor was it ascertained that any article of food eaten upon that occasion could be regarded as a probable medium of infection.

STATISTICAL SUMMARIES

OF

DISEASE AND MORTALITY.

Statistical Summaries of Disease and Mortality.

The statistical information relating to disease and mortality which has been received by the Board during each year, either through the medium of voluntary returns or in consequence of legal requirements, has, in the recent reports of the Board, been presented under four different heads or groups.

The group heretofore presented under the head "Fatality of certain diseases" (diphtheria and croup, scarlet fever, typhoid fever and measles), and that embracing the annual returns of deaths in cities and large towns of the State (Revised Laws, chapter 75, section 12), are necessarily omitted from this report, the data for those tables not being available at the present time.

The two summaries herewith published are defined as follows: —

I. *The Weekly Mortality Returns.* — These consist of the reports of deaths, which are made up weekly and are sent to the office of the State Board by the registration officials of cities and towns. They serve principally to show the seasonal prevalence of each of the chief infectious diseases, and the mortality of children under five years old, in weekly periods. Beginning with the year 1875, this series of statistics has been annually reported (see page 475 of report for that year), and was first published as a summary in the report of 1883.

II. *Reports of Cities and Towns, made under the Provisions of Chapter 75, Section 52, of the Revised Laws.* — By this act each local board of health is required to report to the State Board every case of "disease dangerous to the public health" which is reported to the local board. A digest of these reports is presented in Summary No. II. This summary was first published in the report of 1893, page 639.

NOTE. — A supply of the postal cards, necessary for the reporting of voluntary mortality returns such as are required for the data presented in section I. of the following summary, will be forwarded to the registration officers of any city or town who are willing to contribute the necessary information.

Postal cards are also sent to all boards of health in the State, for the purpose of aiding them to comply with the provisions of chapter 75, section 52, of the Revised Laws, relative to the reporting of diseases dangerous to the public health to the State Board immediately after reports of the same are received by the local board.

Annual blank forms are also sent to each local board of health in cities and towns having over 5,000 inhabitants, for the return of such information as is called for by the provisions of chapter 75, section 12, of the Revised Laws.

I.

The Weekly Mortality Returns.

In the following summary, the voluntary reports of deaths received at the close of each week from the city registrars, town clerks and boards of health of the cities and towns are epitomized for the nine months, January to September, inclusive, 1905. The chief value of this abstract consists in the fact that it presents a continuous history of the mortality from certain specified diseases from week to week.

This weekly report has been published in the Boston Medical and Surgical Journal every week for a period of twenty-five years or more, and also as a publication of the Board, in a weekly bulletin, since and including 1883.

These returns are necessarily incomplete, since they are voluntary and consequently embrace the statistics of a portion only of the population, the reporting places being chiefly the cities and large towns.

The population of the cities and towns contributing to these returns was 2,220,815, or 74 per cent. of the total population of the State.

The following items are embraced in this summary: —

Average height of barometer for each week.
Mean maximum temperature.
Mean minimum temperature.
Rainfall, expressed in inches.
Total deaths reported for each week.
Deaths of children under five years.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diphtheria.
Deaths from scarlet fever.
Deaths from measles.
Deaths from diarrhœal diseases.
Deaths from whooping-cough.
Deaths from puerperal fever.
Deaths from malarial fever.
Deaths from erysipelas.
Deaths from cerebro-spinal meningitis.
Deaths from smallpox.
Deaths from influenza.

The following table contains a summary of the statistics compiled from these weekly returns of mortality: —

Summary, Jan. 1 to Sept. 30, 1905.

1905.	Barometer.	Maximum Mean Thermometer for Each Week.	Minimum Mean Thermometer for Each Week.	Humidity.	Rainfall in Inches.[1]	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diphtheria and Croup.	Scarlet Fever.	Measles.	Diarrhœal Diseases.	Whooping cough.	Puerperal Fever.	Malarial Fever.	Erysipelas.	Cerebro-spinal Meningitis.	Smallpox.	Influenza.
Jan. 7,	29.91	37	21	84	-	702	155	66	129	3	15	2	-	4	2	-	-	2	4	-	-
14,	30.28	34	20	60	-	664	152	56	119	2	18	2	1	7	5	-	-	2	5	1	1
21,	30.03	36	21	62	-	691	159	51	142	3	16	2	1	12	-	-	-	1	2	-	3
28,	29.99	27	11	71	4.09	686	154	62	140	3	17	3	1	4	-	-	-	-	6	-	1
Feb. 4,	30.28	23	10	61	-	783	201	58	171	8	10	4	-	7	1	1	-	4	4	-	-
11,	30.16	31	17	68	-	783	185	80	174	2	10	4	-	5	1	1	-	1	10	-	3
18,	30.01	29	11	62	-	731	164	78	157	5	4	1	2	6	1	1	-	1	8	-	1
25,	30.22	35	21	64	1.67	747	166	66	153	5	10	3	1	9	2	2	-	2	8	-	5
March 4,	29.84	36	19	58	-	687	150	82	119	4	8	2	-	3	2	2	1	2	10	-	3
11,	30.13	39	25	61	-	678	176	68	141	2	5	2	3	9	1	1	-	6	6	-	3
18,	30.31	42	26	54	-	691	180	61	133	4	10	5	3	12	1	-	-	6	12	-	2
25,	30.34	45	33	84	3.14	740	170	66	120	1	8	2	2	7	-	2	-	3	21	-	-
April 1,	30.04	60	42	47	-	759	202	62	129	3	8	3	1	10	2	3	-	3	30	-	2
8,	29.86	49	35	58	-	726	185	73	116	6	12	3	3	11	-	1	-	2	22	-	2
15,	29.74	57	39	67	-	687	174	65	109	4	6	-	3	9	1	1	-	3	25	-	-
22,	29.87	55	37	66	-	677	165	74	97	4	10	3	2	14	2	1	-	2	28	-	1
29,	29.93	59	41	75	2.42	698	168	87	93	1	8	4	3	3	3	1	-	4	27	-	-
May 6,	30.06	65	44	72	-	687	167	72	110	3	7	6	-	10	1	2	-	1	17	1	-
13,	29.98	69	50	70	-	733	195	77	124	5	12	5	3	10	1	1	-	2	22	-	-
20,	29.82	57	46	81	-	647	155	60	84	4	4	3	1	15	2	-	-	1	23	-	-
27,	30.05	70	50	60	1.31	648	166	78	69	3	7	2	3	8	4	1	-	6	16	-	-
June 3,	29.98	71	54	63	-	657	162	55	64	5	11	4	1	11	-	-	-	3	28	-	-
10,	29.95	70	52	73	-	588	145	64	65	2	11	3	3	6	3	-	-	4	14	-	-
17,	29.97	79	63	77	-	571	155	65	58	5	9	2	4	18	2	1	-	1	15	-	-
24,	30.00	72	58	80	5.13	585	152	55	44	2	8	2	3	18	1	2	-	2	10	-	-
July 1,	29.89	76	58	64	-	584	160	71	43	1	7	2	3	34	3	-	-	-	8	-	-
8,	30.01	80	65	76	-	612	188	59	37	5	9	1	4	69	-	-	-	1	13	-	1
15,	30.04	88	69	74	-	715	311	52	30	5	5	-	12	133	1	1	1	2	8	-	-
22,	29.89	85	58	62	-	793	386	49	28	4	2	1	1	227	1	-	-	1	3	-	-
29,	30.00	76	62	70	3.01	739	346	59	34	7	1	-	1	195	3	-	-	1	6	-	-
Aug. 5,	29.88	75	61	79	-	739	327	42	37	8	5	1	2	150	6	1	-	-	6	-	-
12,	30.15	82	69	78	-	828	334	72	27	3	2	-	1	216	5	1	-	-	10	-	-
19,	30.06	68	57	72	-	746	340	55	34	15	3	1	-	196	4	-	-	-	4	-	-
26,	30.01	79	62	73	4.02	796	358	58	28	13	7	1	1	175	3	-	-	2	9	-	-

Sept. 2,	29.96	69	57	77	-	639	260	59	35	8	3	1	1	128	4	-	-	1	6	-	-
9,	30.05	74	60	82	-	638	251	47	38	12	9	-	-	96	4	1	-	2	6	-	-
16,	30.17	67	53	76	-	628	218	67	22	19	6	-	1	84	2	-	-	-	2	-	-
23,	30.03	71	58	81	-	681	272	51	38	26	8	-	-	80	3	1	-	-	2	-	-
30,	30.02	64	48	67	6.01	621	212	63	44	17	8	-	-	47	-	-	-	1	6	-	-
Totals,	-	-	-	-	30.80	27,005	8,166	2,486	3,335	232	319	80	71	2,058	77	29	2	75	462	2	28
Weekly average,	-	-	-	-	-	692.5	209.3	63.7	85.5	5.9	8.2	2.1	1.8	52.8	2.0	0.7	.05	1.9	11.8	.05	0.7
Rate per 1,000 deaths,	-	-	-	-	-	-	302.39	92.06	123.50	8.59	11.81	2.96	2.63	76.21	2.85	1.07	.07	2.78	17.11	.07	1.04
Rate per 1,000 population,[2]	-	-	-	-	-	16.53	5.00	1.52	2.04	0.14	0.20	0.05	0.04	1.26	0.05	0.02	.001	0.05	0.28	.001	0.02

Average reporting population, ... 2,220,815

[1] Rainfall in inches. The amounts in this column are given by months instead of by weeks.

[2] In computing these percentages, allowance is made for the fact that the data cover a period of but thirty-nine weeks.

II.

Official Returns of Notified Diseases Dangerous to the Public Health, 1905.

The figures presented in the following summary are those of the official returns of diseases "dangerous to the public health," made to the State Board of Health during the period from Jan. 1, 1905, to Nov. 30, 1905, inclusive, under the provisions of chapter 75 of the Revised Laws. In this act no disease is specified as being "dangerous to the public health" except smallpox. Hence the State Board deemed it necessary to indicate the diseases which should be included in the meaning of the term "dangerous to the public health." They are the following: smallpox, scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy, trichinosis.

The whole number of cases of infectious diseases reported to the Board from Jan. 1, 1905, to Nov. 30, 1905, under the provisions of this act, was 18,053, which were divided as follows: —

Reported cases of smallpox,	44
Reported cases of scarlet fever,	3,594
Reported cases of diphtheria and croup,	5,059
Reported cases of typhoid fever,	2,794
Reported cases of measles,	6,107
Reported cases of cerebro-spinal meningitis,	455
Total,	18,053

The summary for the twelve years and three months, 1893–1905, is as follows: —

	Reported Cases of —						Total.
	Smallpox.	Scarlet Fever.	Diphtheria and Croup.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.	
1893 (four months only),	35	2,914	1,109	1,525	1,503	–	7,086
1894,	181	6,731	4,178	2,372	2,133	–	15,595
1895,	1	6,194	7,806	2,438	4,868	–	21,307
1896,	5	3,801	8,515	2,637	6,362	–	21,320
1897,	18	5,495	7,613	2,104	12,695	–	27,925
1898,	10	3,667	3,980	2,196	4,478	–	14,331
1899,	105	5,349	7,134	2,776	12,355	–	27,719
1900,	104	6,396	12,641	2,967	10,507	–	32,615
1901,	773	4,356	9,793	2,689	9,398	–	27,009
1902,	2,314	4,613	7,036	2,721	17,249	–	33,933
1903,	422	5,877	6,888	2,955	9,430	–	25,572
1904,	100	4,100	6,772	2,605	12,511	–	26,088
1905,	44	3,594	5,059	2,794	6,107	455	18,053
Total,	4,112	63,087	88,524	32,779	109,596	455	298,553

By months these diseases were reported as follows: —

Cases of Infectious Diseases reported to the State Board of Health by Months from Jan. 1, 1905, to Nov. 30, 1905.

Months.	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
January,	11	407	575	114	730	–
February,	3	385	426	123	495	–
March,	–	429	392	52	667	2
April,	2	409	425	93	576	133
May,	14	416	499	94	710	113
June,	7	351	402	104	896	64
July,	1	186	326	145	548	29
August,	3	117	260	471	145	32
September,	2	190	389	767	95	4
October,	1	295	634	506	266	13
November,	–	409	731	325	979	15
Total,	44	3,594	5,059	2,794	6,107	455

The following table is introduced for the purpose of facilitating the comparison of the seasonal prevalence of the diseases named in the table, in different years. By means of the method employed, the errors due to the difference in the length of the months are eliminated. The figures should be read as follows: for example, the mean daily number of reported cases of diphtheria reported throughout the eleven months, Jan. 1, 1905, to Nov. 30, 1905, was 15.1; of scarlet fever, 10.8; of typhoid fever, 8.4; and of measles, 18.3. During the month of January the mean daily number of reported cases of these diseases was: for diphtheria, 18.5; scarlet fever, 13.1; typhoid fever, 3.7; and for measles, 23.5 (see columns marked A). Assuming a standard of 10 as a daily mean throughout the year for each disease, the ratios for January were as follows: diphtheria, 12.3; scarlet fever, 12.1; typhoid fever, 4.4; and measles, 12.8 (see columns marked B). So that for each 10 cases of diphtheria reported as a daily mean throughout the eleven months, Jan. 1, 1905, to Nov. 30, 1905, there were 12.3 in January, 10.1 in February, 8.3 in March, etc.

From this table it appears that the maximum prevalence of diphtheria was in November and the minimum in August. The prevalence in the last three months was greater than that of the first three months.

The prevalence of scarlet fever was above the mean in January, February, March, April, May, June and November, and below it in the remaining months, the maximum occurring in February and the minimum in August. In the previous year the maximum was in January and the minimum in August.

Typhoid fever was, as usual, below the mean in the intensity of its prevalence in the first seven months, rising to a maximum in September.

The prevalence of measles was above the mean in January, March, April, May, June and November, and below it in the remaining months, the maximum occurring in November and the minimum in September.

Certain Infectious Diseases. Seasonal Intensity of Prevalence.

Months.	Diphtheria.			Scarlet Fever.			Typhoid Fever.			Measles.		
	1905.		1904.	1905.		1904.	1905.		1904.	1905.		1904.
	A	B	B	A	B	B	A	B	B	A	B	B
	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.
January,	18.5	12.3	13.8	13.1	12.1	17.4	3.7	4.4	6.8	23.5	12.8	12.9
February,	15.2	10.1	10.2	13.8	12.8	16.8	4.4	5.2	5.4	17.7	9.7	23.9
March,	12.6	8.3	9.3	13.8	12.8	12.9	1.7	2.0	5.1	21.5	11.7	21.6
April,	14.2	9.4	9.5	13.6	12.6	12.7	3.1	3.7	5.6	19.2	10.5	19.2
May,	16.1	10.7	8.0	13.4	12.4	8.0	3.0	3.6	7.6	22.9	12.5	17.1
June,	13.4	8.9	10.0	11.7	10.8	7.1	3.5	4.2	5.4	29.9	16.3	11.7
July,	10.5	7.0	6.9	6.0	5.6	4.9	4.7	5.6	7.7	17.7	9.7	5.5
August,	8.4	5.6	6.2	3.8	3.5	3.8	15.2	18.1	13.8	4.7	2.6	0.7
September,	13.0	8.6	9.4	6.3	5.8	5.1	25.6	30.5	20.6	3.2	1.7	0.5
October,	20.5	13.6	12.5	9.5	8.8	8.5	16.3	19.4	20.4	8.6	4.7	1.3
November,	24.4	16.2	12.3	13.6	12.6	9.7	10.8	12.9	12.4	32.6	17.8	2.3
Mean,	15.1	10.0	10.0	10.8	10.0	10.0	8.4	10.0	10.0	18.3	10.0	10.0

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns, from Jan. 1, 1905, to Nov. 30, 1905.

	Small-pox.	Scarlet Fever.	Diph-theria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Abington,	-	44	1	6	-	-
Acton,	-	-	-	1	-	-
Adams,	-	37	16	66	3	-
Agawam,	-	-	3	-	-	-
Amesbury,	-	30	2	8	35	-
Andover,	-	16	6	16	-	-
Arlington,	-	36	9	2	3	-
Ashburnham,	-	-	1	-	5	-

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns from Jan. 1, 1905, to Nov. 30, 1905 — Continued.

	Small-pox.	Scarlet Fever.	Diph-theria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Athol,	–	1	–	2	85	1
Attleborough,	–	5	4	1	5	3
Avon,	–	–	–	3	–	–
Ayer,	–	6	–	5	26	–
Barnstable,	–	–	–	3	4	–
Barre,	–	–	11	–	–	–
Becket,	–	–	4	–	–	–
Bedford,	–	–	–	8	1	–
Belchertown,	–	–	–	–	1	–
Bellingham,	–	–	3	–	1	
Belmont,	–	13	3	–	2	–
Berlin,	–	–	–	–	–	1
Beverly,	–	19	38	35	15	1
Billerica,	–	2	40	5	–	–
Blackstone,	–	–	1	–	–	–
Boston,	5	984	1,326	795	1,181	152
Braintree,	–	38	2	3	–	1
Brewster,	–	–	1	1	–	–
Bridgewater,	–	2	–	–	–	–
Brockton,	–	68	16	81	13	3
Brookfield,	–	–	1	8	–	–
Brookline,	–	49	34	11	45	8
Cambridge,	–	124	307	94	75	20
Canton,	–	–	1	–	3	–
Carver,	–	–	–	2	–	–
Charlton,	–	–	1	1	–	–
Chelmsford,	–	14	4	4	147	2
Chelsea,	–	40	55	37	39	–
Cheshire,	–	–	–	1	73	–
Chester,	–	–	1	1	–	–
Chicopee,	–	4	25	12	61	1
Chilmark,	–	1	–	–	6	–
Clinton,	–	4	9	–	299	–
Concord,	–	22	2	9	2	–
Cottage City,	–	–	–	–	4	–
Dalton,	–	9	7	–	–	–

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns from Jan. 1, 1905, to Nov. 30, 1905 — Continued.

	Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Danvers,	-	27	48	11	5	1
Dartmouth,	-	2	1	-	-	-
Dedham,	-	22	1	4	30	-
Deerfield,	-	2	-	1	-	-
Dighton,	-	4	9	-	-	-
Douglas,	-	1	-	1	-	-
Dracut,	-	1	2	-	-	2
Dudley,	-	1	5	8	1	-
Duxbury,	-	1	5	2	8	-
East Bridgewater,	-	-	4	1	8	-
Easthampton,	-	-	4	8	-	3
East Longmeadow,	-	3	20	1	1	-
Easton,	-	4	1	11	-	-
Erving,	-	1	1	-	-	-
Essex,	-	-	1	1	30	1
Everett,	3	49	51	40	60	2
Fairhaven,	-	2	1	2	1	-
Fall River,	-	59	85	80	4	9
Falmouth,	-	-	25	-	1	-
Fitchburg,	-	11	42	12	231	-
Foxborough,	-	2	2	2	-	-
Framingham,	-	3	-	2	-	-
Franklin,	-	16	7	5	-	1
Gardner,	-	8	8	12	12	-
Georgetown,	-	-	1	-	-	-
Gill,	-	-	-	-	7	-
Gloucester,	-	9	71	9	2	1
Grafton,	-	2	1	-	2	-
Granville,	-	-	-	1	-	-
Great Barrington,	-	13	4	-	-	1
Greenfield,	-	7	11	4	120	-
Groton,	-	2	-	-	2	-
Groveland,	-	7	3	-	3	-
Hadley,	-	4	1	1	40	-
Halifax,	-	-	-	1	-	-
Hamilton,	-	-	-	-	-	1

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns from Jan. 1, 1905, to Nov. 30, 1905 — Continued.

	Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Hardwick,	–	12	–	2	–	–
Harvard,	–	1	–	1	–	–
Harwich,	–	–	–	–	–	7
Hatfield,	–	–	6	–	7	–
Haverhill,	1	24	53	49	444	8
Hingham,	–	11	5	–	–	–
Hinsdale,	–	2	4	–	6	–
Holbrook,	–	2	2	–	–	–
Holden,	–	–	1	10	–	1
Holliston,	–	9	1	1	1	–
Holyoke,	–	37	137	10	262	8
Hopedale,	–	9	1	2	1	–
Hopkinton,	–	–	1	–	–	–
Hudson,	–	–	–	4	2	–
Hull,	–	–	1	1	1	–
Huntington,	–	1	–	1	–	–
Hyde Park,	2	31	21	15	1	4
Ipswich,	–	10	1	13	–	–
Kingston,	–	2	2	5	–	–
Lakeville,	–	5	–	–	–	–
Lancaster,	–	1	1	–	63	–
Lawrence,	6	86	87	89	455	31
Lee,	–	21	4	4	–	–
Lenox,	–	3	–	–	–	1
Leominster,	–	12	15	9	16	–
Lexington,	–	5	5	–	3	–
Lincoln,	–	4	–	–	–	–
Longmeadow,	–	1	1	1	1	–
Lowell,	22	45	175	34	106	86
Lunenburg,	–	–	–	–	3	–
Lynn,	1	99	57	64	276	16
Malden,	–	36	78	49	36	–
Manchester,	–	3	1	–	3	–
Mansfield,	–	14	10	3	4	–
Marblehead,	–	2	19	5	2	1
Marion,	–	1	–	–	–	–

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns from Jan. 1, 1905, to Nov. 30, 1905 — Continued.

	Small-pox.	Scarlet Fever.	Diph-theria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Marlborough,	–	12	–	12	6	–
Marshfield,	–	–	1	2	–	–
Maynard,	–	2	11	4	26	–
Medfield,	–	2	3	–	–	–
Medford,	–	35	44	21	16	2
Medway,	–	2	3	1	3	–
Melrose,	–	42	28	4	308	1
Mendon,	–	1	–	–	–	–
Merrimac,	–	17	1	–	–	–
Methuen,	–	12	11	8	10	–
Middleborough,	–	18	11	–	3	2
Middleton,	–	–	2	1	–	–
Milford,	–	9	11	2	–	–
Millbury,	–	2	–	3	7	–
Millis,	–	–	–	–	–	1
Milton,	–	13	7	1	66	–
Monson,	–	7	7	16	40	–
Natick,	–	14	2	2	4	–
Needham,	–	6	5	–	–	–
New Bedford,	1	59	137	49	125	2
Newbury,	–	–	8	2	–	–
Newburyport,	–	10	17	25	14	–
Newton,	–	71	65	15	27	4
North Adams,	–	32	138	29	11	–
Northampton,	–	14	51	11	8	–
North Andover,	–	14	10	3	28	–
North Attleborough,	–	4	8	–	7	–
Northborough,	–	3	2	1	2	–
Northbridge,	–	1	2	–	8	–
North Brookfield,	–	–	–	1	7	–
Northfield,	–	4	3	–	27	–
Norton,	–	15	–	–	–	–
Norwell,	–	2	1	1	2	–
Norwood,	–	41	15	–	3	–
Oakham,	–	–	1	–	–	–
Palmer,	–	3	7	4	3	–

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns from Jan. 1, 1905, to Nov. 30, 1905 — Continued.

	Small-pox.	Scarlet Fever.	Diph-theria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Paxton,	–	1	–	–	–	–
Peabody,	–	3	15	1	–	3
Pepperell,	–	18	–	–	126	–
Pittsfield,	–	56	13	34	17	4
Plymouth,	–	9	6	3	9	5
Princeton,	–	–	1	–	5	1
Provincetown,	–	–	7	–	–	1
Quincy,	3	35	84	14	12	8
Reading,	–	7	3	2	4	–
Rehoboth,	–	1	–	–	–	–
Revere,	–	5	19	7	–	2
Rochester,	–	–	1	–	–	–
Rockland,	–	8	–	49	10	–
Rockport,	–	3	2	1	–	–
Rowley,	–	1	–	13	–	–
Royalston,	–	1	–	3	4	–
Russell,	–	1	–	1	–	–
Rutland,	–	–	–	7	–	–
Salem,	–	37	264	46	120	7
Salisbury,	–	–	1	10	3	–
Sandisfield,	–	3	–	–	–	–
Saugus,	–	4	15	–	–	–
Scituate,	–	1	8	1	–	–
Sharon,	–	4	–	1	4	–
Sheffield,	–	2	–	–	–	1
Shelburne,	–	–	1	–	–	–
Sherborn,	–	–	1	–	–	–
Shirley,	–	1	3	–	2	–
Shrewsbury,	–	–	1	–	–	–
Somerville,	–	103	168	43	13	5
Southampton,	–	3	–	–	–	–
Southborough,	–	1	–	1	–	–
Southbridge,	–	4	134	4	–	–
South Hadley,	–	2	12	1	39	–
Southwick,	–	1	–	–	–	–
Spencer,	–	1	5	1	–	–

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns from Jan. 1, 1905, to Nov. 30, 1905 — Continued.

	Small-pox.	Scarlet Fever.	Diph-theria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Springfield,	–	88	197	161	107	1
Stockbridge,	–	1	1	–	1	–
Stoneham,	–	7	–	–	14	–
Stoughton,	–	8	1	–	10	–
Stow,	–	2	1	–	–	–
Sturbridge,	–	–	6	–	–	–
Sudbury,	–	–	–	1	–	–
Sutton,	–	2	1	–	1	1
Swampscott,	–	10	1	5	8	–
Swansea,	–	1	2	1	1	–
Taunton,	–	47	35	9	–	1
Templeton,	–	4	–	1	55	-
Tewksbury,	–	3	1	–	2	2
Tisbury,	–	–	–	–	7	–
Tolland,	–	2	–	–	–	–
Topsfield,	–	9	–	2	–	–
Townsend,	–	2	–	–	17	–
Tyringham,	–	1	–	–	–	–
Upton,	–	2	–	1	–	–
Uxbridge,	–	1	–	–	1	–
Wakefield,	–	26	6	10	5	4
Walpole,	–	18	1	1	1	–
Waltham,	–	35	29	96	1	2
Ware,	–	7	24	–	–	–
Wareham,	–	–	–	–	–	1
Watertown,	–	19	122	6	6	2
Wayland,	–	1	–	–	39	–
Webster,	–	1	11	–	14	1
Wellesley,	–	7	–	1	2	–
Westborough,	–	3	–	2	1	1
West Boylston,	–	1	–	–	4	–
West Bridgewater,	–	2	–	–	–	–
Westfield,	–	21	13	46	9	1
Westford,	–	–	1	–	1	–
Westminster,	–	–	1	–	35	–
Weston,	–	4	–	–	1	–

Cases of Infectious Diseases reported to the State Board of Health from 239 Cities and Towns from Jan. 1, 1905, to Nov. 30, 1905 — Concluded.

	Small-pox.	Scarlet Fever.	Diph-theria.	Typhoid Fever.	Measles.	Cerebro-spinal Meningitis.
Westport,	–	2	2	–	8	–
West Springfield,	–	3	12	2	–	–
Westwood,	–	2	1	1	–	–
Weymouth,	–	38	14	4	–	–
Whitman,	–	7	2	2	3	–
Wilbraham,	–	3	3	–	1	–
Williamstown,	–	3	16	7	8	–
Wilmington,	–	2	–	–	1	–
Winchendon,	–	3	–	–	36	–
Winchester,	–	4	5	1	7	–
Winthrop,	–	9	8	5	3	1
Woburn,	–	5	18	26	15	–
Worcester,	–	69	109	127	157	10
Wrentham,	–	1	–	1	1	–
Yarmouth,	–	4	1	1	–	–
Totals,	44	3,594	5,059	2,794	6,107	455

Anthrax occurred in the following place: —

Lynn,	1

Leprosy occurred in the following places: —

Boston,	1
Wareham,	1
Total,	2

List of Cities and Towns from which no Reports were received.

I. Cities.

None.

II. Towns having a Population of More than 5,000.

Amherst, Orange. — 2.

III. Towns having a Population of More than 1,000 but Less than 5,000 in Each.

Acushnet,
Ashland,
Auburn,
Bourne,
Buckland,
Charlemont,
Chatham,
Clarksburg,
Cohasset,
Colrain,
Conway,
Dennis,
Edgartown,
Freetown,
Hanover,
Hanson,
Hawley,
Heath,
Holland,
Hubbardston,
Leicester,
Littleton,
Ludlow,
Mattapoisett,
Montague,
Nantucket,
New Marlborough,
Norfolk,
Orleans,
Oxford,
Pembroke,
Plainville,
Randolph,
Raynham,
Sandwich,
Seekonk,
Somerset,
Sterling,
Warren,
West Brookfield,
West Newbury,
West Stockbridge,
Williamsburg. — 43.

IV. Towns having Less than 1,000 Inhabitants.

Alford,
Ashby,
Ashfield,
Berkley,
Bernardston,
Blandford,
Bolton,
Boxborough,
Boxford,
Boylston,
Brimfield,
Burlington,
Carlisle,
Chesterfield,
Cummington,
Dana,
Dover,
Dunstable,
Eastham,
Egremont,
Enfield,
Florida,
Gay Head,
Goshen,
Gosnold,
Granby,
Greenwich,
Hampden,
Hancock,
Lanesborough,
Leverett,
Leyden,
Lynnfield,
Mashpee,
Middlefield,
Monroe,
Monterey,
Montgomery,
Mt. Washington,
Nahant,
New Ashford,
New Braintree,
New Salem,
North Reading,
Otis,
Pelham,
Peru,
Petersham,
Phillipston,
Plainfield,
Plympton,
Prescott,
Richmond,
Rowe,
Savoy,
Shutesbury,
Sunderland,
Truro,
Tyngsborough,
Wales,
Warwick,
Washington,
Wellfleet,
Wendell,
Wenham,
Westhampton,
West Tisbury,
Whately,
Windsor,
Worthington. — 70.

A supply of postal cards for the purpose of reporting infectious diseases to the State Board of Health, as required by statute, will be forwarded to any local board of health on application to the secretary of the State Board, Room 141, State House, Boston.

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